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DAVID HUNT LINDER

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David Hunt Linder was born in Brookline, Massachusetts on September 24, 1899. From Noble and Greenough School he entered Harvard where he received his A.B., A.M., and Ph.D., in 1921, 1922, and 1926 respectively. During these years of study he served as assistant in Botany at Harvard in 1920–1921 and as Austin Teaching Fellow in 1922–1923. His first position was at Washington University, St. Louis, first as instructor from 1926–1929 and later as Assistant Professor from 1929–1931. During this period he was also mycologist for the Missouri Botanical Garden from 1927–1931. He returned to Harvard in 1931 and during the next two years was instructor in Botany. In 1932 he was made Acting Curator and two years later appointed Curator of the Farlow Herbarium and Library at which time he also became Lecturer in Botany. These positions he held for the remainder of his life. His study and teaching was supplemented by rich experience in field work. He spent the summer of 1922 in Nova Scotia serving as field assistant to Professor M. L. Fernald and in 1923–1924 collected and studied fungi in British Guiana as a Sheldon Traveling Fellow. In the summer of 1924 he assisted W. H. Weston on a survey of sugar cane diseases under the Tropical Plant Research Foundation, and in 1926–1927 gained further field experience as Botanist for the Harvard African Expedition to Liberia and the Belgian Congo. He arranged and participated in the active and productive summer forays of the Mycological Society of America. As a member of this Society he was particularly active, holding the offices of Secretary-Treasurer from 1936–1938, Vice President in 1939, President in 1940 and Counsellor in 1942 and 1943. He also represented the Society at the 6th International Botanical Congress in Amsterdam, Holland in 1935. In addition he was a member of the following societies: The New England Botanical Club, The Torrey Botanical Club, The Botanical Society of America, The Society of Plant Taxonomists, The British Mycological Society and The American Association for the Advancement of Science. His publications included nearly fifty papers dealing with a wide range of botanical subjects as well as with his own special field of the lower Basidiomycetes and certain groups of the Fungi Imperfecti. His career was terminated by his death on November 10, 1946.

Thus briefly can one sum up in a paragraph the essential activities of a life of valuable, contributive, scientific work. Such information, essential

though it may be, is wholly inadequate to do justice to the work of even the most inactive and unproductive. Certainly it is consummately inadequate to give any measure of evaluation of the active and contributive life of David Linder. Each mycologist, however humble or however great, has in some measure added to his own area of the field of science. Linder's contributions in the 20 highly productive years of his activity from 1926 to 1946 were notable and varied.

For his research Linder was internationally known especially for his authoritative monographic studies of certain difficult groups of the imperfect fungi. His monographs of the Helicosporeae, extensive and thorough, placed this previously little-known group of fungi on a sound basis. Similarly, his monographic studies of other hyphomycetous genera such as *Oidium* organized series of species previously in unfortunate confusion. Additional work extended our knowledge of other orders of the Imperfecti, such as the Sphaeropsidales and the Melanconiales, adding significant new genera and species and clarifying classification and relationships in the group. Not only in the Fungi Imperfecti but also in the Basidiomycetes his work contributed materially to mycological knowledge. His work on this extensive group ranged from studies of lower forms such as members of the Tremellales to his thorough monograph of the genus Schizophyllum among the Hymenomycetes and to research on various members of the Gasteromycetes.

His published papers include work of equally high standing in practically all of the major groups of fungi, and his knowledge of mycology as a whole was notably broad in its range and thorough in its comprehension. Although most of his work is concerned with terrestrial fungi, he was thoroughly familiar with the specialized aquatic groups, describing from British Guiana, early in his career, a distinctive new species of *Araiospora*, the most elaborate genus of the fresh-water Phycomycetes. Within recent years he collaborated in pioneer work on the hitherto unsuspected fungi that live submerged in sea water, his careful taxonomic studies of these unusual Fungi Imperfecti and Ascomycetes opening up a new field of investigation and revealing a group beautifully adapted in structure and development for successful survival and distribution under marine conditions.

An impressive number of more than 20 new genera and over 150 new species were established by him in the various groups on which his work centered, and so thorough and accurate were his studies that the position of these fungi new to science is secure and it seems highly improbable that any of them will be relegated to synonymy in the future or suffer serious changes in their taxonomic standing. It is deeply to be regretted that his monographic studies of an extensive series of species of *Exobasidium* which he had collected, grown in artificial culture and compared with exacting attention to the details of their development and cytology, will be left unfinished, for the members of this group are of especial interest, not only because of their injurious parasitism on cranberries, blueberries

and other valued members of the Ericaceae, but also because of their somewhat controversial position in the taxonomy of the Basidiomycetes as a natural group.

His productive work extended also even beyond the broad field of mycology, revealing a competency and versatility unusual in this day of specialization. His field work on the vegetation of Liberia and the Belgian Congo, resulting in a well-chosen collection of over 1600 specimens, added to our knowledge of the flora of those regions, and his very readable account of the occurrence, distribution, ecology and importance of the plants encountered on this African expedition reveals his wide botanical grasp. Similarly, his work on the lichens of the Galapagos and of Guadalupe and on the diatoms of the famous pre-Columbian fishweir excavated in Boston's historic Back Bay are further evidence of the breadth of his skill. Additional papers on mycological nomenclature and on the decisions reached on taxonomy and nomenclature at the sessions of the International Botanical Congress show his interest and his competency in these fundamental aspects of mycology, while his work on the evolution of the Basidiomycetes is stimulating in its effective grasp of the significance of the basidium as a means of interpreting the phylogeny of this large and highly developed group.

The several and very able joint contributions in which he collaborated with others furnish convincing evidence that, although preeminent as an independent investigator, he cooperated helpfully and effectively with his colleagues in creative projects, but it is notable that he never exploited joint authorship for his own advantage, hence the publications of students who worked for higher degrees under his guidance always appeared as contributions by the student himself, even though Linder in most cases had chosen and formulated the research problem and in all cases had contributed materially to the successful completion of the work.

The value of his contributions was enhanced by the versatility and artistry which he applied to illustrating them and the superlative accuracy and technical skill of his many drawings reveal the high standards of exactness and perfection which characterize all his work. He was quick to see the possibilities in various methods used by illustrators in non-scientific fields and versatile in applying these techniques to the illustration of his own mycological contributions. While the drawings in his early papers were done in conventional line and stipple with water-proof ink on Bristol Board, he soon turned to the potentially more flexible medium of the gypsum-coated stipple boards manufactured by Ross, and the success with which he developed this technique to bring out complicated three dimensional forms, surface modifications and various types of protoplasmic content is beautifully shown in the plates of his monograph of the Helicosporeae. He experimented also with the process employed by some commercial artists of using various patterns of stipple printed on thin transparent cellophane cut out and applied to cover suitable areas of the drawing, thus supplementing the ink stipple applied directly with the pen. Later,

turning to sheet celluloid, the texture of which suited his sure and skillful touch, he made on this medium many effective plates such as those illustrating his studies of *Coemansia* and *Oidium*, and developed very effective means of applying the "Sgraffito" technique for transitions of shading from solid black through intermediate tones to open line and stipple. In the last few years he had been experimenting with the "Craftint" method used by commercial illustrators for building up depth and tone of shading by brushing developing solutions onto the surface of prepared papers chemically impregnated with stipple patterns and the highly effective illustrations of some of the new genera and species on which he was working at the time of his death show his skill with this medium. These plates were used to illustrate the paper he presented at the Mycological Society meetings at St. Louis in March 1946, and will appear later in this journal when the descriptions of these striking new forms he found concerned in the tropical deterioration of textiles are completed by others who were associated with him in this work during the war.

Also, he was a master of photography and although only a small portion of the illustrations in his papers were of this sort, he effectively used various types of photography as helpful tools in his work. His early efforts included some excellent nature photographs of birds and plants in their natural habitats. Later he concentrated more on photographic illustrations of fungi not only in black and white but also in various color processes from the early Lumière to the later developments of Kodachrome and Kodacolor. Some of his high magnification photo micrographs of important structural features of fungi are unusually excellent and it was the cost of half-tone reproduction rather than any prejudiced preference for line and stipple drawings which prevented his using many of these high power photographs for illustration. His considerable skill in motion picture photography was not devoted directly to scientific ends as much as to supplementary illustration of mycological forays and other field work in which he was interested.

In other techniques contributive to his mycological work he was also highly skilled. After testing a wide variety of methods for making permanent mounts of the fungi with which he worked he at first recognized the suitability of Amann's lactophenol mounting medium and of Noyer's rosin-lanolin cement for sealing the coverglass on slides thus prepared. Later he even more successfully applied the double coverglass method of Diehl using pure glycerin as the mounting medium and synthetic resins for sealing. For the last two years he had been experimenting with a clear synthetic polymer, Plexigum, developed by Rohm & Haas, and had found in this material notable advantages for sealing the cover-glasses of microscopic mounts.

Although primarily concerned with taxonomy, nomenclature, relationship, phylogeny and similar aspects generally considered to be the more academic aspects of mycology he had a keen appreciation and quick grasp of the practical importance of the fungi. His address as retiring President

of the Mycological Society at its meeting in Philadelphia in late December 1940 gave timely expression to his sincere conviction that mycologists should be of helpful service in the war effort and pointed out the ways in which they could render effective aid to such essential activities as plant pathology, agriculture, and medicine and to such productive manufacturing as the textile industry and the commercial fermentations. It is, therefore, not surprising that, although he is most widely known for his outstanding work in fundamental mycology, he had, both independently and in helpful collaboration with others, contributed significantly to many fields of applied mycology.

In the field of plant pathology he collaborated with various investigators, helpfully contributing to their work on rots of timber trees, on destructive leaf spots of various crops in the United States, China and Latin America, and on injurious rusts and smuts of tropical and temperate plants. Left unfinished was the extensive work he was carrying on in collaboration with Dr. G. W. Fischer toward a monographic treatment of the smuts as a group. Also contributive to plant pathology were his studies of diseases of elm trees in Missouri, of the diseases of coffee, cacao, coconuts, and other important tropical plants in Dutch Guiana, of diseases of sugar cane in Cuba, and on such diseases as the black thread infection of rubber trees, the mosaic of cassava, and the red ring of coconut palms in Liberia.

To his medical colleagues he rendered invaluable aid by applying his unusually wide mycological knowledge to the stubborn and baffling fungi that are disfiguring or injurious in their attack on superficial human tissues such as the skin, hair and nails, or deadly in their invasion of more vital organs. In medical mycology he was not only helpful in his identification of the fungi concerned but also in his suggestions as to techniques of isolation and culture which proved to be of material aid in solving difficult problems. In the field of the importance of fungous spores in the air as causers of unusual types of inhalant allergy he not only aided his medical colleagues by authentic identification of puzzling forms but afforded them helpful guidance by his keen analysis of their problems from the mycological point of view.

In the field of horticulture his studies of the fungi which are essential to the growth of orchids developed improved methods for culturing and applying these fungi for the successful growing of highly prized orchid hybrids.

His suggestion, in his Presidential Address in 1940, that mycologists could be of aid to the textile industry through their knowledge of the fungi that cause the mildewing of cloth, foretold prophetically the field in which he was to render great service four years later, for during the war his tropical experience and his wide knowledge of the fungi were of great value in critical technical aspects of research on the deterioration of valuable equipment and supplies in the tropics. Since under tropical conditions mildew, mold, rot and other forms of fungous injury were notably accentuated, particularly on such necessarily exposed and highly valuable textiles

as tentage and tarpaulins, the program initiated by the Office of the Quartermaster General for the study and control of such losses was an important one.

In this program one of the first and essential phases was the determination of the identity, nature and abundance of the agents, chiefly fungi, which were involved. Among the activities of the Tropical Deterioration Administrative Committee, under Project AN14 of the National Defense Research Committee, there was established at Harvard Contract OEMsr–1389, from September 1944 through October 1945, followed by Quartermaster Corps Contract QM60 from November 1, 1945 through June 30, 1946, to carry on work on this phase of the program.

Since the effectiveness of this work was in large measure dependent on the thoroughness of the study and dependability of the identification of the fungi concerned in deterioration, the part played by Linder in his part-time work on these contracts during this period was an essential contribution. At Harvard over 4500 cultures of fungi were received, isolated, purified, studied, maintained and conserved for use in other phases of the program. In all, some 4025 of these were identified and while many of these were identified by specialists in certain difficult genera, such as *Penicillium* and *Fusarium*, the bulk of the identifications were made by Linder. The thoroughness of his work is evidenced by the fact that very few of even the most puzzling and baffling fungi encountered remained unidentified. Without his expert knowledge of the fungi as a whole and his especial familiarity with some of the more difficult groups of the Fungi Imperfecti, the accomplishment of the main objectives of the work of these contracts would not have been possible. His competence in this highly specialized technical field was appreciatively recognized by scientific members of the administrative groups of both the National Defense Research Committee and the Quartermaster Corps and his contribution to this phase of the war effort was gratefully acknowledged by the Office of the Quartermaster General.

In contrast to some mycologists who are highly competent in laboratory and herbarium investigation but ineffectual in field work, Linder was an exceedingly competent field worker, a keenly discerning observer, a collector with an uncanny gift for finding the rare but inconspicuous forms missed by others, a naturalist in the best sense. He never lost sight of the fact that a herbarium specimen, however excellent, is but a static representation of a living organism and that a pure culture in a tube or flask is not growing under the conditions which surround it in nature. In his boyhood he showed early aptitude as a naturalist and his eagerness for direct, first-hand study of living things in the surroundings in which they naturally grew was fostered first by his sympathetic and understanding parents as he grew up in the happy and favorable country environment of Canton, Massachusetts, and later by stimulating contacts with his great-uncle William Gilson Farlow, and by work with Dr. M. L. Fernald, whom he accompanied on field trips in New England during his college years and

assisted in a botanical collecting trip in Nova Scotia in the summer of 1922. His first extensive trip on his own to British and Dutch Guiana in 1923 on a Sheldon Fellowship from Harvard gave him a vivid and memorable introduction to the botanical luxuriance of the tropics and gained for him an unusual background of first-hand experience with the rich fungous flora of that relatively untouched region. While assisting on a survey of the losses from sugar cane diseases in Cuba in the summer of 1924, he not only gained practical experience in plant pathology but also, since he was a keen observer and an indefatigable collector, extended his knowledge of other tropical fungi and acquired considerable valuable material, some of which became the subject of later publications. His field experience as botanist on the Harvard African expedition to Liberia and the Belgian Congo in 1926 and 1927 under the direction of Dr. R. P. Strong of the Harvard Medical School gave him an unusual opportunity for further development as a botanist, and as might have been predicted he not only fulfilled his job as botanist with the highest competency but also as a mycologist enriched his rapidly growing knowledge by his eager study of the rich flora, and by collecting valuable material for later work. Although the bulk of his work on this expedition was with the higher plants, it is notable that in the collection of over 200 fungi which he assembled he showed such a flair for interesting and significant material that among the specimens he collected significant additions to science are still being uncovered. The remarkable and distinctive new genus *Linderella*, which he collected in Banga, Liberia and which will be described in full in a later number of this journal, is but another example of his unusual discrimination as a collector.

This eagerness for field work he never lost even when the pressure of responsibilities as Curator and Lecturer at Harvard made any long trips to distant localities impossible. He collected and carried on field work actively in this vicinity and on his brief vacations either took an active part in various forays of the Mycological Society or on his summer trips by automobile combined the happy objectives of visiting his many botanical friends and of collecting extensively from Canada and upper New England in the north, to the Great Smoky Mountains in the south.

As a teacher he was especially effective in guiding investigation of the material itself, hence unusually stimulating in instigating and fostering the research of more advanced students. To the development of the seven graduate students who attained their Ph.D. degrees under his helpful and stimulating guidance he contributed notably and their work has maintained a standard of excellence highly creditable not only to themselves but to him. He has been characterized as being neither a colorful nor a compelling lecturer and this criticism is just for he was not at ease when lecturing and found it difficult to present material spontaneously. Realizing this he was extremely painstaking in the preparation of his lectures, assembling in careful and effective organization a wealth of material thoroughly covering the subject and usually writing out his lectures in finished

form wholly suitable for publication, to be read in full as written. His lectures, therefore, made up in organization and in coverage what they may have lacked in colorful presentation and they were highly valuable to the student interested in the subject and eager to gain a sound knowledge of it. At times, as when giving informal accounts of his travels and mycological field work in such fascinating regions as British and Dutch Guiana or Africa he lost his constraint and his lecturing became wholly interesting and enjoyable.

While the criticism of his lecturing is just, it in no sense implies that he was not successful as a teacher. On the contrary, with small groups of interested workers under informal conditions or when concerned directly with the material itself he showed himself to be a born teacher, informative, enlightening and stimulating. He had the qualities essential for effective teaching: a natural and contagious enthusiasm, a stimulating and original point of view, a keen analysis of problems, a wealth of pertinent information sincerely and directly given. These characteristics were so fundamentally a part of him that they were not reserved for his informal teaching in the laboratory but made him a stimulating and informative member of any group with which he was associated. It was these qualities that made him notably successful in the many contacts involved in his activity as Curator of the Farlow Herbarium and every visiting worker, whether interested amateur, neophyte student, travelling Fellow, or recognized authority in some special field, gained help and impetus from association with him. It was these qualities also, in addition to his expert knowledge, that contributed to the success of the contract work on the fungi concerned in deterioration during the war, and the members of this research group were indebted repeatedly to his unusual ability to sense the extent of their knowledge and to supply the timely suggestions that rapidly improved their techniques and skills and expedited the progress of the work. Since he had a very practical understanding of what effective teaching actually involved, Linder was not overawed by impressive programs and pretentious plans for new thaumaturgies in Education (in capitals and with a resplendent halo) but it was notable that in any constructive departmental or academic activities he was always ready to contribute his full share of hard work. Following the same general pattern he would gladly devote a large amount of time and effort to developing a man's ability to do productive research of the highest caliber but was not inclined to spend hours of inconclusive discussion to foster a student's tendencies to theoretical speculation in nebulous realms of biological philosophy.

For his work as Curator of the Farlow Herbarium and Library Linder is perhaps most widely known and it is the opinion of some that this was his greatest contribution to Botany. Becoming Acting Curator in 1932, after the death of Dr. Thaxter, he served in this capacity for two years so effectively that he was appointed Curator on September 1, 1934, thus devoting in all fourteen years to this phase of his life's work. At the very outset his objective was clear: — to make the Farlow Herbarium and

PLATE II

Another informal portrait of Dr. Linder taken by Dr. Vincent Dethier at the Farlow, probably in 1941.

Library a productive and functional institution of useful service to Botany. To this purpose he devoted himself wholeheartedly, achieving a large measure of success despite the handicaps of very inadequate funds and of merely lukewarm backing from the University administration. He not only maintained the Farlow in its long standing position of prestige but further augmented its material assets and its usefulness until it is now preeminent in its field. Since 1932 nearly 18,000 items, many of them of especial value and all of them of significant utility, have been added to the Library while the Herbarium has been increased by over 200,000 specimens including such valuable lots as the Bartholomew and Blackford collections of fungi, the Haynes and Verdoorn collections of hepatics, the Scott collection of algae, the Cheever collection of diatoms, and the Sprague collection of lichens. The scientific value of these accessions can be appreciated only if one appraises them according to Linder's own exacting standards, insisting that a herbarium must be a functional adjunct to field and laboratory work and must consist not of impressive numbers of inactive accumulations but of vitally useful material, the essential tools for active investigation. The scope to which he extended the usefulness of the Herbarium can be estimated from the fact that under his direction a total of over 50,000 specimens were sent on loan to experts in this country and abroad to aid them in their investigations in pure and applied fields. The usefulness of both the Herbarium and Library was increased also by his developing and extending the several essential index file systems that facilitate rapid finding of pertinent material.

The amount of work that was necessary to achieve all this can be appreciated only by those who have served in similar capacities, and in addition there were the demands of carrying on a voluminous correspondence, of identifying large numbers of specimens, of teaching and other academic duties. It is not surprising that his own research was done chiefly in the evenings at his home. Since Philip Rusden, in his sympathetic and thorough biographical note which should appear in Mycologia before this is published, has emphasized Linder's curatorial activities in full with pertinent data supplied by Miss Hilda Harris from her 14 years' association with the Farlow as librarian, no further details need be given here.

There are, however, certain additional points that should be noted. Linder has been criticized for doing too much of the routine work instead of relegating it to others and there is some basis for this criticism but it should be remembered that his conscientiousness would not permit him to lower his standards and that his staff, although competent and loyal, was inadequate in number and could not be increased because of limited funds. To the administrator, usually predominantly endomorph in psychosomatic pattern, the overconscientiousness of an ectomorph scientist, who would scrub floors himself rather than have a dirty laboratory greet visiting botanists, is naturally incomprehensible and open to criticism. Criticism has been raised also against the reiteration in his yearly reports of the

need for more adequate support if the Farlow Herbarium and Library was to meet its responsibilities. On reading over these reports, the writer finds no querulous complaining that would justify annoyance, but rather a steady, restrained insistence on what Linder felt it was his duty as Curator to emphasize. Also these reports reveal a competent man devoted to his work, the type of man who, if those in power had dealt with him directly in occasional conferences instead of delegating the job to others, would readily have cooperated in some constructive compromise. It should be noted that in all his years as Curator the insistence was always on the inadequacy of support for the Herbarium and Library with never any complaining about his own comparatively meagre and perennially static salary.

Under Linder's curatorship the atmosphere of the Farlow became congenial and cooperative, highly conducive to productive work by visiting botanists. The priceless and irreplaceable type materials, the rare and valuable books were conserved, not by hoarding them as functionless accumulations under jealous and selfish guardianship, but by giving them the greatest possible usefulness, yet through judicious care and thorough efficient organization and ingenious devices such as typeslides making them serviceable, while conserving them for future service. Thus the Farlow served not as an end in itself, a monumental repository for hoarded collections, but as a functional means to the end of furnishing the unequalled material which, in the hands of competent investigators with Linder's stimulating aid, resulted in the production of contributions valuable to science. It was only natural, therefore, that the fame of the Farlow Herbarium and Library became widespread in this country and abroad so that botanists from many different institutions came to work there in ever-increasing numbers and the Visitors' Book became a roster of those productively active in various areas of Cryptogamic Botany. With many of these Linder maintained contact through an extensive correspondence, stimulating their productive work and aiding them with his unusual knowledge and with loans of helpful material. His aid to beginners was effective and encouraging, his collaboration with advanced specialists highly productive, as several joint papers in different fields of mycology testify. More than this, he was a genial host, a stimulating consultant and a helpful associate so that all of the visiting botanists who spent even short periods working at the Farlow found that through him they gained much more than mere access to the material and volumes pertinent to their work.

His early plans for extending the usefulness of the Farlow Herbarium and Library were thoroughly sound and showed far-sighted vision and it is to be regretted that limited funds and support prevented carrying out his program. It was his hope to foster monographic studies of genera, particularly among the fungi of importance to medicine and to plant pathology, by securing fellowships to aid those competent to carry on such work. It was his hope also to establish curatorships of the various groups of

cryptogams so richly represented in the Farlow collections and thus to stimulate productive work on these groups. It was his hope to establish a periodical of wide scope and ample space, since the series of "Contributions from the Cryptogamic Laboratories and from the Farlow Herbarium" to which he contributed many significant papers had, as he realized, the unavoidable limitations of the journals in which the separate numbers appeared. The establishment of "Farlowia" in January 1943 was the fulfillment of one of his plans of 1934 and the result of his long realization of the need, expressed in his presidential address of 1940, of a taxonomic journal for Cryptogamic Botany that would be a publishing outlet for monographs of greater length than could be accommodated by the existent periodicals with their necessary restrictions as to the acceptable length of papers. That "Farlowia" has won a definite place for itself in these four years is the result not only of meeting this long-foreseen need but also of his own efforts and those of Edgar Seeler, Miss Harris and others of the staff to maintain the high standards he had set.

The pattern of Linder's years of constructive activity, so briefly summarized at the very beginning of this paper, thus takes form commanding our admiration and our respect. Yet this is inadequate and incomplete without the color and warmth of his personality, the quickening vitality of his qualities as a man as well as a scientist. Sincerity and loyalty together with integrity and undeviating adherence to the highest standards were inherent in his nature and gave him strong qualities of leadership. In him there was an enduring dependability and an unfailing courage. Unselfishness, helpfulness and consideration for others were dominant qualities which characterized him throughout his life. Natural friendliness and spontaneous hospitality were characteristic of him as were a keen sense of humor and a ready wit.

It was his personality that gave color and vitality to his activities. To his students his friendliness and his sympathetic understanding of their problems enriched his careful teaching and his competent guidance of their research. To his colleagues, as to all those who were associated with him in his years of work at the Farlow Herbarium and in the Department of Biology at Harvard, it was his qualities as a man as well as his unusual ability in his own field that made working with him so congenial. The loyalty of the staff at the Herbarium and Library was in response to his leadership and the esprit de corps which distinguished that small but productive group of workers stemmed from him. Similarly in the long hours of work under the war contracts his genial personality contributed much to the spirit which made those years of intense, concentrated activity so vivid and memorable.

His personality as well as his recognized preeminence as a mycologist contributed both to his success as Curator of the Farlow Herbarium and Library and to the wide prestige of that institution. The many letters that arrived after his death became known are moving in their tribute to him, warm evidence that even a brief period of scientific work at the Farlow

Herbarium was to the visiting botanists a rich experience, memorable, quite apart from the material facilities, both for the many ways in which Linder fostered and aided their investigation and for his stimulating companionship and natural hospitality. The temptation to quote from all of these is strong but perhaps one example will serve. J. R. Bartholomew, whose work on Diatoms is well known and whose long association with Linder had involved contributive activity as Honorary Curator of Diatoms and as one of the editorial board of "Farlowia," wrote appreciatively of the turning point in his own work when, feeling that "making hooked rugs would be more useful to humanity" than his investigation of Diatoms, he turned to Linder and received from him the dynamic stimulus ("every time he lit a cigarette he had a new idea") that reoriented and revitalized his investigations. His concluding paragraph typifies what Linder's curatorship at the Farlow meant to a large number of workers in many fields: —

"Diatomists as a rule are amateur scientists. They are apt to take themselves seriously, possibly because no one else does, and hence as a rule established Herbaria and their Curators are apt to look down their noses when these pariahs and outcasts knock at the door. Let no one make this statement about Dr. Linder or the Farlow. One could always find a place to work, a magnificent library and friendly, inspiring cooperation."

The lighter side of Linder was thoroughly delightful, an enlivening part of the unusual combination of qualities which endeared him to his friends. His ready wit was part of this and his quickness for just the touch of comic relief that fitted the occasion. He had an aptitude for mimicry and for genial and kindly fooling. It was these qualities as well as the informal training in field work which have made the days in the country with him so happily remembered by the students who in groups of sometimes as many as a dozen used to be invited every weekend from April through June to his home on the outskirts of St. Louis. The same enlivening touch was treasured by the students who worked with him at Harvard and, in the activities of the graduate scientific fraternity, Gamma Alpha, it was this which helped make him one of the most well-liked of the faculty members. In the Farlow Herbarium this touch contributed to the geniality of the atmosphere, and in the brief but enjoyable respite for tea and coffee in the afternoon it was interspersed with the serious and productive shop talk. Perhaps it will not be out of place to mention one or two characteristic incidents. When "Farlowia" was being established and mailing lists for the preliminary prospectus were being assembled, Mrs. Riddle, who had done the major part of this work, was told that if she brought the list to two thousand this achievement would be commemorated by a special issue with her picture on the cover in place of the head of Dr. Farlow. Since this goal was approximately attained, Linder, by retouching a photograph of Mrs. Riddle, prepared a silhouette which was adroitly stuck on in place of that of Farlow. So neatly was this done

that for a time she was completely taken in and appropriately disturbed that the first issue should be thus embellished.

Also, although guests were usually taken by Linder to the more pretentious Faculty Club for lunch, those who worked for some time in the Herbarium would often join the enjoyable informal staff lunches in the front room. On one of these occasions when Dr. H. S. Jackson of Toronto was a guest, the conversation, amid discussions of phylogeny in the Basidiomycetes, was turned adroitly by Linder to comparison of food shortages in the United States with those in Canada. As an example of how much more the shortage had affected Cambridge, Dr. Linder, with the impish gleam in his eye familiar to his close friends, said that eggs had grown notably smaller and smaller in consequence and at this point set before Dr. Jackson two boiled starling's eggs gathered for the occasion from the nests of some of the many starlings which, quite appropriately, had also found the Farlow a congenial place for productive work. It is characteristic of Linder's blend of happy foolery and scientific curiosity that once the jest had been effectively sprung and the eggs had been opened with due ceremony he was much interested by the fact that these eggs, although much smaller and boiled for the same time as the hen's eggs that had been kept in reserve, were still only slightly coagulated.

His unfailing courage was so unobtrusive that only those of us who were close to him realized how often it sustained him through the handicaps of his long years of suffering from high blood pressure. He continued his work with a staunchness that won the admiration of all of us. Only the drawn look around his eyes, and the beads of perspiration on his upper lip revealed the strain he was undergoing and only rarely, with the quiet remark that he would have to go home and lie down, would he show the toll which the frequent splitting headaches were exacting from him. He had in large measure the quality of grace under adversity. This, together with his other fine qualities, contributed notably to making him the best sort of companion on expeditions, especially when the going was really grim. In our many months of field work together in Cuba there were many such occasions that demonstrated this quality of his, and companions on the African Expedition have spoken warmly of how great an asset to the group, even under the most difficult and trying situations, Linder invariably proved.

It is understandable that those of us who had been closely associated with him can not quite realize that he is gone. The sense of loss from his death is deepened by the realization that at the age of 48, many years of the productive work he enjoyed should still have stretched before him.[1]

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[1] Since the complete list of Dr. Linder's publications compiled by Miss Hilda Harris, Librarian of the Farlow Library, has already appeared in Mycologia, accompanying Philip Rusden's biographical sketch, the reader is referred to that article, and the list will not be duplicated here. (See Mycologia **39**: 133–144, 1 pl. 1947.)

3(2): 155–157 FARLOWIA JULY, 1947

COSCINOIDS AND COSCINOCYSTIDIA IN LINDEROMYCES LATERITIUS

ROLF SINGER

Several tropical species of *Paxillus* are remarkable because of their large, rough, warty, or reticulate spores. The author has (*in* Ann. Mycol. **40**:59. 1942) tentatively placed all these species in the genus *Phyllobolites* with a Brazilian species, *P. coccineus* Rick, as type species. In spite of all the efforts of Dr. Rick and other Brazilian colleagues, the type could not be located and seems to be lost. Later collections proved to be misdeterminations (also according to J. Rick *in litt.*), and belong to *Paxillus panuoides* and *Pleurotus* sp. Under the circumstances, it appears that the existence of *Paxillus coccineus* is highly doubtful.

The author's efforts to study the type material of another rough-spored *Paxillus* were more successful. Thanks to a loan of the type material of *Paxillus lateritius*, a species described by Petch from Ceylon, the author is now in a position to confirm the independent generic status of this species. It is unique because of the presence of a conductive system unknown, thus far, in Agaricales in particular, and apparently in fungi in general. The whole carpophore consists of two types of elements, (1) ordinary hyphae which are hyaline or nearly so, filamentous, and provided with clamp connections and thin walls that collapse easily, and (2) of numerous conducting elements that differ from all known types of laticifers, oleiferous hyphae, gloeo-vessels, etc. by their curious sieve- or sponge-like structure (see Text Fig. 1). They are long, filamentous, aseptate, brown bodies with a pitted, sieve-like surface. The perforations of the surface, however, do not lead, as might be expected, into a tubular cavity as in other conductive elements; they are merely the orifices of densely mean-

TEXT FIG. 1. Fragment of a coscinoid in the type of *Linderomyces lateritius*, at first treated with KOH, then dyed with phloxine and imbedded in Shear's mounting fluid × 1200. Photomicrograph Singer & Frank White.

dering holes of the same diameter as the orifices, and separated by a wall substance that is colored deep brown by an insoluble membrana-pigment in the sense of Kühner. The whole structure can therefore be compared with a filamentous sponge. Only the apices of these elements are sometimes hair-like, and, rarely, septate without clamps.

This new type of conductive element is called **coscinoid** by the author — (koskinion-sieve).

The coscinoids project in both the cortical and the hymenial layers of the carpophore, forming cystidia-like terminal bodies, perpendicular to the surfaces, and parallel to the basidia, many of them projecting beyond the level of the sterigmata and the tips of the cuticular elements. In a general way, therefore, they may be considered as pseudocystidia and dermatopseudocystidia; yet they differ from all known types of pseudocystidia in their structure which is identical with that of the coscinoids from which they are hardly separated, and usually little differentiated. Their apices are either obtuse or acute, and their diameter is from 2.5 to 10 μ.

This new type of pseudocystidium is called **coscinocystidium** by the author.

The coscinoids that run through the hymenophoral trama are distributed in a strongly divergent-bilateral arrangement, *i.e.* they curve outwards from a central axillar strand, in both directions bending into a nearly 90° turn toward the hymenium. This divergence is more distinct and sudden than in *Paxillus involutus*, and probably more so than the divergence of the normal hyaline hyphae of *Paxillus lateritius* itself; but in the type specimen, these hyphae are not well enough preserved to allow a comparison.

The bilateral trama and the brownish spores, together with the macroscopical features, prove that this plant belongs in the family Paxillaceae. In fact, its external appearance is strongly reminiscent of *Paxillus involutus*. However, there are also numerous differences. The spores are actually rough, as described by Petch, and more voluminous than in any species of *Paxillus*, *viz* 9.3 — 13.5 $\times$ 5.2 — 10.2 μ. The spore ornamentation is difficult to interpret since it is not chemically different from the main episporium, also not deeper colored than the optical background. The outline of the spore in optical section is minutely wavy, and the rugosities seem to be due to alternating thickenings in the wall. This structure is very unlike that in the punctate spores of *Crepidotus*, sect. *Echinospori*, and *Tubaria thermophila* where the episporium is interrupted by deeper colored imbedded short-cylindric punctations, and it is also different from the ornamentation of *Cortinarius* where deeper colored warts form an outer layer (exosporium?) between the episporium and perisporium. As might be expected, there is no plage (smooth suprahilar spot) in the suprahilar depression of the spores of *Paxillus lateritius*. In the cuticle whose structure is not clearly decipherable in the material at hand, the author observed a bright yellow pigment that is soluble in ammonium hydroxide and probably intercellular, much like the pigment found in the hymenophore of

Pulveroboletus auriporus (Peck) Sing. Cresyl blue stains did not reveal any remarkable metachromatic coloration of the spores or the hyphae. Alkali darkens all sections of the fungus.

All these characters demonstrate that *Paxillus lateritius* is not congeneric with *Paxillus involutus*, nor with any other species described in *Paxillus* or in other genera.

It is therefore proposed as the type species (*typus generis*) of a new genus, *Linderomyces*, named in honor of David H. Linder, the late curator of the Farlow Herbarium, and a dear friend and co-worker. Always interested in the work accomplished by the members of the staff, always generous with valuable suggestions and ready to help when necessary, he was witness to the discovery of the strange anatomical features of Petch's type, and had hoped to take part in its further examination and illustration shortly before his last illness set an end to all his plans.

LINDEROMYCES, gen nov.

Genus Paxillacearum; carpophoris pileatis, centraliter stipitatis, reactione alcalina atrofuscescentibus, hymenophoro lamellari infero praeditis, pigmento laeto coloratis; siccis brunnescentibus, in vegeto carnosis, phaeosporis, terrestribus. Habitu Paxillum involutum in mentem revocante; lamellis confertis, subsimplicibus, angustis; carne autoxydatione mutante; hyphis hyalinis, filamentosis, fibulatis, tenuitunicatis; elementis coscinoideis numerosis, brunneis; coscinocystidiis in hymenio et in cuticulis praesentibus; tramate hymenophorali bilaterali; sporis voluminosis, brunneolis, ellipsoideis, asperulatis, disco levi in depressione suprahilari destitutis. Ad terram.

Typus generis est **Linderomyces lateritius** (Petch) Sing. comb. nov. = *Paxillus lateritius* Petch.

The author wishes to express his gratitude to the Director of the Royal Botanic Gardens, Kew, England, for the loan of the type specimen of *Paxillus lateritius*.

FARLOW HERBARIUM
HARVARD UNIVERSITY
CAMBRIDGE, MASSACHUSETTS

THE MARINE ALGAE OF OREGON

PART II. RHODOPHYTA

MAXWELL S. DOTY

There follows a continuation of the annotated systematic list of the marine algae of Oregon which began with the Chlorophyta and Phaeophyta in Part I.[1]

DIVISION RHODOPHYTA

RHODOPHYCEAE

BANGIALES

ERYTHROTRICHIACEAE

ERYTHROTRICHIA Areschoug, 1850

Erythrotrichia Welwitschii (Ruprecht) Batters, 1902:55; — Smith, 1944:163. *pl. 36, figs. 1–2.*

Arising from a monostromatic base on rocks and corallines at South Bay (*MD 5048*, July). The filaments often with spores and with geniculations resulting from the enlargement of one or more cells originally cut off in a diagonal manner.

Erythrotrichia sp.

With intramatrical rhizoids descending from the basal 6–12 cells; filaments about 35 μ in diameter throughout; cells in the upper portion often longitudinally divided and about one third as long as broad.

With and on *Ulva vexata* (*MD 6114*, north shore of Chetco Cove).

Erythrotrichia pulvinata Gardner, 1927a:238. *pl. 24, figs. 1–3*; — Smith, 1944:164. *pl. 36, fig. 3.*

On skeleton of *Strongylocentrotus purpuratus* (sea urchin) lodged at the HHLW levels, Middle Bay, July (*MD 4894b*).

ERYTHROCLADIA Rosenvinge, 1909

Erythrocladia irregularis Rosenvinge, 1909:73; — Smith, 1944:166. *pl. 37, fig. 1.*

On the main axes of *Antithamnion* (*MD 5028b*) at Lighthouse Beach, and elsewhere on other algae.

Erythrocladia subintegra Rosenvinge, 1909:73; — Smith, 1944:166. *pl. 36, fig. 6.*

On *Scytosiphon* and *Ilea* (*MD 2454*, July) at Squaw Island and on other algae elsewhere.

BANGIACEAE

BANGIA Lyngbye, 1819

Bangia vermicularis Harvey, 1858:55. *pl. 49*; — Smith, 1944:167. *pl. 37, figs. 4–6.*

Common throughout the range. Cystocarpic material of this species has

[1] Part I. Chlorophyta and Phaeophyta. Farlowia **3** (1):1–65. 1947.

been collected on rocks and was intermingled with *Urospora penicilliformis* (*MD 6181b*, Rogue River Reef, July, at the plus 2.0 foot level). In fertile segments of uniseriate filaments, each cell had undergone two divisions with each of the four resultant cells putting forth a trichogyne. These filaments were 23–25 μ in diameter in the fertile portion. Filaments collected in summer are relatively slender, short and dark purple in color; and they become longer as the season progresses. In winter and early spring thalli of this species are much larger, brownish, and at times hollow.

PORPHYRA C. Agardh, 1824

Porphyra naiadum Anderson, *apud* Blankinship & Keeler, 1892:148; — Smith, 1944: 169. *pl. 40, fig. 1.*

Throughout the range on *Phyllospadix* and *Zostera*. There seems to be no qualitative difference between the forms *major* and *minor* of Hus (1902: 213).

Porphyra nereocystis Anderson, *apud* Blankinship & Keeler, 1892:149; — Smith, 1944:171. *pl. 37, fig. 7.*

Epiphytic on *Nereocystis* throughout the range. The abundance of this alga varies greatly from year to year.

Porphyra schizophylla Hollenberg, *apud* Smith & Hollenberg, 1943:213. *figs. 6–7*; — Smith, 1944:173. *pl. 39, fig. 4*; *pl. 40, fig. 4.*

Growing above the top of the *Pelvetiopsis*-zone above the LHLW [2] level to a height of 14–20 feet above mean lower low water. Since this is about 15 feet above the level of the usual high tides and 11 feet above the very highest tides, this alga lives where spray or rain is the only source of moisture. From the appearance when collected in early July (*MD 6201*, Harris State Park) it seems clear that it must be a winter or early spring species. The thalli were fruiting but the uppermost members of the stand were very pale in color and appeared more or less dead. The alga at the above locality was on the vertical faces of rocky islets facing the ocean. Both spermatangial and carposporic material was collected. Another collection (*MD 6186*) was made at Otter Point from the same habitat.

The Oregon material, while less eroded and more discolored than the type material in the Dudley Herbarium (*306400*), compares very well with it in texture, stature, and general coloration. The anatomical details are also similar to the type. However, the cell lumina are somewhat smaller and the cells, especially those of the carposporic material, are pyriform but with the narrowed ends directed outward. The trichogynes are very slender and at times almost as long as the long diameter of the cell producing them.

Porphyra lanceolata (Setchell & Hus) G. M. Smith, *apud* Smith & Hollenberg, 1943: 213. *figs. 8–10*; — Smith, 1944:170. *pl. 38, figs. 1–2*; *pl. 40, fig. 3.*

Throughout the range and often pendant from overhanging rocks, us-

[2] For a detailed characterization of these levels see Doty, 1946.

ually at approximately the HHLW level or just above, but one collection at Middle Bay (*MD 4112*) was in the spray zone.

Porphyra perforata J. Agardh, 1883:69; — Smith, 1944:172. *pl. 39, fig. 5.*

Throughout the range between HHLW and LHLW tide levels. Usually on rocks but at times epiphytic on *Iridophycus* and other algae.

Porphyra occidentalis Setchell & Hus, *apud* Hus, 1900:69; — Smith 1944:174. *pl. 39, fig. 1.*

Throughout the range south from Cape Arago on rocks between the MLLW and LLLW levels.

There are three different forms referred to this species. For the most part the thalli of the specimens alloted to this species are 11–15 cm. broad and up to 100 cm. long. However collections have been made more than once of thalli less than 2 cm. broad and up to 15 cm. long. In some collections the thalli are of a deeper violet color, deeply incised and 5–8 cm. broad by 20 cm. tall. These three forms are quite similar in microscopic dimensions. When fruiting all three have the same characteristic slimy texture, and male thalli have the same yellow-green margins. Homothallic with the carposporic areas lying inward from the spermatangial area. The fertile female area with relatively few sterile cells. Carpospores in packets of 16.

Porphyra variegata (Kjellman) Hus, 1900:69; — Smith, 1944:173. *pl. 38, fig. 3.*

On rocks nearly buried in the sand just below the HHLW level along the northeast shore of Sunset Bay in June (*MD 4593*) and at Squaw Island (*MD 2358*).

Porphyra miniata var. **cuneiformis** Setchell & Hus, *apud* Hus, 1900:68; — Smith, 1944:174.

Thalli up to 30 cm. tall and 10 cm. broad, distromatic, 47 μ thick, flaccid, violaceous pink, margins plicate but otherwise flat; base very broadly cordate; cells squarish in surface view and in irregular rows, average diameter, 17 μ; fruiting areas inconspicuous, narrow and marginal.

At Cape Arago on the rocks of the old jetty in Coos Bay (*John Queen 37*). Also taken from the stomach of the common fish, *Aspocottus bison.*

This is listed in the above references as "forma *cuneiformis.*"

Porphyra Thuretii Setchell & Dawson, *apud* Dawson, 1944:253; — Smith, 1944:171. *pl. 40, fig. 2.*
Porphyra leucosticta Hus (*non* Thuret) 1902:199. *pl. 20, figs. 1–3.*

Washed ashore in abundance onto the beach south of Chetco Cove once in July (*MD 6099*).

PORPHYRELLA Smith & Hollenberg, 1943

Porphyrella Gardneri Smith & Hollenberg, 1943:215. *figs. 13–14*; — Smith, 1944:175. *pl. 37, figs. 2–3.*

At Squaw Island, Middle Bay, Cape Blanco and cast ashore on the beach south of the Chetco River and probably throughout the intervening region. Usually on *Laminaria Andersonii* but occasionally on other kelps.

Some of the blades in the Chetco River material (*MD 6113*) are much larger than the type in the Dudley Herbarium (*306401*) being up to 20 cm. long and 8 cm. broad. The other Oregon collections are quite similar to the type.

NEMALIONALES

CHANTRANSIACEAE

ACROCHAETIUM Nägeli, 1862

Acrochaetium Desmarestiae Kylin, 1925:10. *figs. 4a–f.*

On *Desmarestia munda* at Cape Perpetua (*MD 6304*) and along the old jetty in Coos Bay (*MD 2698*).

Acrochaetium pacificum Kylin, 1925: 11. *figs. 4g–i.*

On *Polysiphonia* growing on *Nereocystis* attached to the wharf at Charleston (*MD 1930a*).

Acrochaetium variabile (Drew) Smith, 1944: 179.

On *Pterygophora* stipes at South Bay (*MD 2163*) and on *Pterochondria* at Charleston (*MD 1930b*).

Acrochaetium amphiroae (Drew) Papenfuss, 1945:312.
Rhodochorton amphiroae Drew, 1928:179. *pl. 40, figs. 34–37*; — Smith, 1944:183. *pl. 40, figs. 5–7.*

On the host, *Calliarthron regenerans*, throughout the range.

RHODOCHORTON Nägeli, 1862

Rhodochorton purpureum (Lightfoot) Rosenvinge, 1900:75; — Papenfuss, 1945:327.
Rhodochorton Rothii (Turton) Nägeli, 1861:121. *figs. 1 and 3*; — Smith, 1944:182. *pl. 41, figs. 1–2.*

At very high tide levels in a shaded cave at Brookings (*MD 6197*) in July. In Gardner's notebooks under number 2740, there is a record of this species with the note, "common in vicinity of lighthouse," Cape Arago. One collection (*MD 6036*) was made from a crustose alga growing on *Tegula funebralis* at South Bay in January.

The rhizoidal base penetrating the crustose alga (*MD 6036*) and giving rise to several long filaments; the filaments in turn unbranched except at the apex where a few alternate or unilateral few-celled corymbose branchlets give rise to tetrasporangia. Cells thick-walled, evenly cylindrical, about 17 (12–19) x 26 μ as a rule. Terminal cell of the filaments rounded. Tetrasporangia terminal on few-celled (1–2) clustered terminal branchlets, broadly obovate, up to 19 x 24 μ. Individual thalli are less than 2mm. high.

HELMINTHOCLADIACEAE

CUMAGLOIA Setchell & Gardner, 1917

Cumagloia Andersonii (Farlow) Setchell & Gardner, *in* Gardner, 1917:399; — Smith, 1944:189. *pl. 42, fig. 2.*

Throughout the range at HHLW or higher; usually hanging from the tops of boulders.

CHAETANGIACEAE

GLOIOPHLOEA J. Agardh, 1871

Gloiophloea confusa Setchell, 1914b:118; — Smith, 1944:190. *pl. 42, fig. 1.*

In large tidepools and on rocks between MLLW and LLLW levels. Found at Brookings in June and July (*MD 6148* and *2592*) and at Agate Beach in July (*MD 4761*).

GELIDIALES

GELIDIACEAE

GELIDIUM Lamouroux, 1813

Gelidium caloglossoides Howe, 1914:96. *pls. 34–35, fig. 7*; — Smith, 1944:194. *pl. 44, figs. 3–4.*

Forming low dark patches in crevices and on vertical sides of shaded rocks between HHLW and LHLW at Cape Arago.

Gelidium pusillum (Stackhouse) LeJolis, 1863:139; — Smith, 1944:195. *pl. 44, fig. 1.*

With *Ceramium Eatonianum* at Sunset Bay (*MD 4179*, December); and on large boulders and at tidepool margins between HHLW and LHLW at South Bay (*MD 4209*, January), and elsewhere on Cape Arago in the winter.

Gelidium pulchrum Gardner, 1927f:279. *pls. 50–53.*

In sand-filled tufts in tidepools from HHLW level downward; from Seal Rocks (*MD 2676*, July) south, but particularly abundant about Cape Arago.

Gelidium Coulteri Harvey, 1853:117; — Smith, 1944:196. *pl. 44, fig. 5.*

Forming hemispherical tufts between LHLW and MLLW levels southward from North Bay (*MD 2691*, July).

Gelidium sinicola Gardner, 1927f:278. *pl. 47, fig. 2.*

Two collections made in January at South Bay (*MD 4098* and *4099*). This species grew in soft irregular clumps of erect fronds just above LHLW in a tidepool. Except for its more bushy nature the collection (*MD 4098*) is quite like the type. Some of the shoots in the collection *MD 4099* possess flattened axes whereas the type material does not have them.

CRYPTONEMIALES

DUMONTIACEAE

CRYPTOSIPHONIA J. Agardh, 1876

Cryptosiphonia Woodii J. Agardh, 1876:251; — Smith, 1944:200. *pl. 45, fig. 2.*

Throughout the range at LHLW to MLLW tidal levels.

Tetrasporangia very irregularly cruciate, 70–75 x 115–140 μ.

PIKEA Harvey, 1853

Pikea pinnata Setchell, 1899, *in* Collins *et al.*, Phyc. Bor.-Amer. fasc. 13:648; — Smith, 1944:202. *pl. 45, fig. 3.*

Throughout the range between MLLW and LLHW.

While *Pikea pinnata* is certainly a distinct and regularly occurring form, if not a distinct species, most all of the material in the herbaria available is assignable to *P. nootkana* and the developmental sequence outlined under that species.

Pikea nootkana (Esper) comb. nov.

Fucus nootkanus Esper, 1802:30. *pl. 125* (heft 5).

Pikea californica Harvey, 1853:246 and 1858:131. *pl. 49, fig. B*; — Collins *et al.*, 1901, Phyc. Bor.-Amer. fasc. 18:897; — Smith, 1944:202. *pl. 46, fig. 3.*

Leptocladia conferta Setchell, 1912:252. *pl. 30*; — 1912, *in* Collins *et al.*, Phyc. Bor.-Amer. fasc. 37: 1848; — Smith, 1944:206. *pl. 46, figs. 4–5.*

Forming bright red hemispherical tufts between MLLW and LLLW throughout the range but particularly abundant along the southern Oregon coast.

It is clear from the figures that Esper gives for *Fucus nootkanus* and Harvey gives for *Pikea californica* that the two are the same. This being the case the earlier specific name of Esper must be used.

From at least some cells of the axial filament there are 4 quadrately disposed filaments. In age the thalli thicken below by multiplication of rhizoids growing down around and through the axial filament to produce a rounded main axis. In some cases the main axis becomes flattened and broadened, and in such forms the axial filament is compressed by the increased number of rhizoidal filaments. In these latter forms the burying of the lower portions of lateral branchlets increases the breadth of the flattened axis. With increased age and thickening of the major axes the pinnate arrangement of the lateral branchlets becomes irregular — apparently because of shedding of some of them. Other branchlets elongate and become rounded and thus produce false dichotomous branching in the thallus. Similar false dichotomies are found when the original main axis is broken off and pinnules below the break elongate. This growth form, rounded below but flattened and thin above, is the *Pikea californica* and *Fucus nootkanus* of Harvey and Esper respectively. The thin terminal portions may weather away or be destroyed during rough weather or winter seasons. Increased rhizoidal growth and increased production of the irregular dichotomies results in the growth forms known as *Leptocladia conferta*. All of these forms may be found throughout the range.

FARLOWIA J. Agardh, 1876

Farlowia mollis (Harvey & Bailey) Farlow & Setchell, 1901, *in* Collins *et al.*, Phyc. Bor.-Amer. fasc. 18:898; — Smith, 1944:204. *pl. 47, fig. 5.*

Farlowia crassa J. Agardh, 1876:262; — Smith, 1944:205. *pl. 46, fig. 1.*

Throughout the range between MLLW and LLLW.

There seems to be only one entity present north of central California

that can be placed in this genus. The species is very variable in regard to thickness and branching. The Port Orford record of *F. crassa*, listed by Smith, is based on a specimen from Collins' herbarium now in the University of California herbarium (number *266456*), and is *F. mollis*. An isotype (*E. Hall*, Oregon) of *F. crassa* and a co-type from San Diego, both in the same herbarium, show more irregular, sometimes unilateral branching from a rather thicker somewhat more asymmetric axis than typical for *F. mollis*, but these slight differences do not seem a justification for considering them to represent separate species.

DILSEA Stackhouse, 1809

Dilsea californica (J. Agardh) Schmitz, *in* Engler & Prantl, 1897:520; — Kylin, 1941:8.
Sarcophyllis californica J. Agardh, 1876:265.
Sarcophyllis californica forma *pygmeae* Setchell, 1897, *in* Collins *et al.*, Phyc. Bor.-Amer. fasc. 8:396.
Dilsea pygmaea Setchell, 1901:126.

Thalli blade-like with a medulla of more or less densely interwoven filaments and an outer cortex consisting of rows of small cells underlain by a subcortex of large granular cells; 180 — 360 μ thick; cystocarps forming first in the apical regions and the cells of the young carposporophyte appearing like gland cells in surface view and like clusters of gland cells in section, with no ostiole; gland cells if truly present at all, irregular in appearance and certainly entirely absent in most of our material; not slimy to the touch when fresh; tending to dry dark colored on herbarium sheets.

Throughout the range above the MLLW level and frequently in dense stands with the blades split irregularly along irregularly incurved lines. *MD 6198*, Harris State Park in July, compares well with the Phyc. Bor.-Amer. number cited, as does *MD 6184* from Otter Point.

Kylin finds the fertile type material (herbarium of J. Agardh number *35900*, collected by E. Hall in Oregon and sent to Agardh by Farlow) to have the reproductory structures characteristic of the *Dumontiaceae*. The tetraspores are produced in a mass from the large subcortical cells and form an extensive layer between the cortex and the medulla. When dried material is resoaked the cortical layers have a strong tendency to separate from the medulla through this mass of subcortical cells. See page 176 for vegetative distinction from *Schizymenia pacifica* Kylin.

CONSTANTINEA Postels & Ruprecht, 1840

Constantinea simplex Setchell, 1901:127; — Smith, 1944:207. *pl. 47, fig. 6.*

Throughout the range in exposed places below LHLW.

In especially favorable well-aerated crevices or exposed ledges this species often forms dense stands of small thalli. Because of their brownish color and small size these at one time were tentatively considered by the author as a different species from the usual large red form.

GLOIOSIPHONIACEAE

GLOIOSIPHONIA Carmichael, 1833

Gloiosiphonia verticillaris Farlow, 1889:3. *pl. 88, figs. 5–6, 9–10*; — Smith, 1944. 209. *pl. 47, fig. 1.*

Common in the early summer months on the sides of large boulders between the HHLW and LHLW levels. In the Brookings area and at Rouge River Reef (Otter Point, *MD 6174*). Also collected once by O. R. O'Neal at Sunset Bay.

?Gloiosiphonia californica (Farlow) J. Agardh, 1885:10; — Smith, 1944: 209. *pl. 47, fig. 2.*

There is one collection made by Gilbert Shearer on the old jetty in Coos Bay in June (*MD 2718*) that is questionably referred here. Since there seem to be two opposite lateral filaments arising from each cell of the single axial filament, or in many cases only one, this sterile specimen may be a form of *Cryptosiphonia*. However, the texture and coloration is like that of *G. californica*.

GLOIOPELTIS J. Agardh, 1842

Gloiopeltis furcata (Postels & Ruprecht) J. Agardh, 1851:235.

PLATE 11, FIG. B

Thalli terete, dichotomously divided, up to 6 cm. tall with the branches largest (up to 3 mm.) about two-thirds of the distance from the base to the apex of the main axis; thalli tapered to a short filiform stipe below and to slender, usually divaricate tips above; texture tough and gelatinous; surface smooth when sterile, and usually remaining so when dried; branches with a large continuous cavity and the cortex consequently thin.

Throughout the range but most conspicuous at the southern end of the state.

In the Brookings area, where this is most abundant and best developed as to size, this is the conspicuous indicator, at least during the early summer months, of the highest regularly occurring algal zone. This zone extends upwards from the LHHW level. It is exceeded only by the irregularly occurring *Porphyra schizophylla*, *Rhodochorton violaceum*, and *Prasiola meridionalis* in our range. In the lower portion of the zone occupied by *G. furcata* it may intermingle with *Endocladia*, *Gigartina*, and *Pelvetiopsis*, but on smooth surfaces of regular contour it is strictly above them.

ENDOCLADIACEAE

ENDOCLADIA J. Agardh, 1841

Endocladia muricata (Harvey) J. Agardh, 1847:10; — Smith, 1944:211. *pl. 47, figs. 3–4.*

This is the dominant member of the association between the HHLW and LLHW tide levels. Doty (1946, p. 321–322, and fig. 2 and 6) probably should have consistently given this vertical distribution. Common throughout the range.

SQUAMARIACEAE

PEYSSONELIA Decaisne, 1841

Peyssonelia pacifica Kylin, 1925:25. *fig. 12b–d, 13*; — Smith, 1944:212. *pl. 48, fig. 3.*

Throughout the range from LHLW levels downward.

Forming bright red patches up to 15 by 30 cm. These patches at times confluent. Bright red, rough surfaced and thin at first, but becoming dark red and more smooth at maturity; drying red.

RHODODERMIS Crouan, 1852

Rhododermis Georgii (Batters) Collins, 1906:106.
Rhodophysema Georgii Batters, 1900:377. *pl. 414. figs. 8–13.*

In Gardner's notebooks under number *2720* this species is listed as "growing on narrow eel grass in tidepool, middle littoral zone. Shore acres south of Cape Arago Lighthouse. . . ." In the same place there is evidence that a considerable amount of material was collected and preserved and studied, but this material was not found.

HILDENBRANDIA Nardo, 1834

Hildenbrandia occidentalis Setchell, *apud* Gardner, 1917:393. *pl. 33, fig. 4*; — Smith, 1944:125. *pl. 49, fig. 4.*

Throughout the range, above the LLHW level.

CRUORIACEAE

PETROCELIS J. Agardh, 1852

Petrocelis franciscana Setchell & Gardner, *apud* Gardner, 1917:391. *pl. 33, fig. 1*; — Smith, 1944:217. *pl. 48, fig. 1.*

Throughout the range on rocks between LHLW and LLHW levels. Forming black shiny irregularly shaped areas of indefinite extent. Tetrasporangia produced in January (*MD 4119*, Middle Bay); about 20 μ in diameter.

CORALLINACEAE

CORALLINA Linnaeus, 1758

Corallina densa (Collins) comb. nov.
Corallina gracilis var. *densa* Collins, 1906:112; — Smith, 1944:230. *pl. 50, figs. 3–5.*

Throughout the range as far north as Cape Arago where it is common at all stations below LHLW. In Gardner's notes (number *2719*) *C. gracilis* var. (forma) *multiramosa* is recorded from Cape Arago.

Corallina chilensis Decaisne, *apud* Harvey, 1847:103; — Smith, 1944:230. *pl. 51, fig. 4.*

Throughout the range in a wide variety of form.

JOCULATOR Manza, 1937

Joculator delicatulus sp. nov.
Frondes erectae, usque ad 2 cm. altitudine; ramificatio irregulariter opposita, apici-

bus ramorum amiorum saepe antenniferis; intergenicula cuneata, 1 mm. longitudine per 2 ad 3 mm. latitudine, in parte ramorum superiore manifeste complanata, in basibus ramorum angustiora rotundatioraque, supra fere omnia ramusculum simplicem, aut ramulum compositum axi parenti similem, aut, praecipue ad basim, ramulos antenniferos, rhizoidiformes, teretes ferentia; conceptacula ad superficiem intergenicularem complanatam saepe restricta, conceptacula terminalia, autem, in apicibus ramorum antenniferorum ordinariorumque et saepe in ramusculis simplicibus lateralibus inveniuntur.

Fronds erect, up to 2 cm. tall; branching irregularly opposite and with the apices of major branches often antenniferous; intergenicula cuneate, 1 mm. long by 2 — 3 mm. broad, those in upper portion of branches conspicuously flattened, narrower and more rounded at the bases of branches, almost every one above bearing either a simple ramule (*i.e.*, a terminal intergeniculum borne on the upper margin of the parent intergeniculum near the terete axial portion of this latter and separated from it by just one geniculum), or a compound branchlet similar to the parent axis, or, especially near the base, terete antenniferous rhizoid-like branchlets; conceptacles often restricted to one flattened surface; narrow intergenicula usually with two conceptacles and these on the wing surfaces, and on very broad intergenicula often a third conceptacle appears on the terete axial portion; terminal conceptacles are found at the apices of both antenniferous and normal branches and often on the simple lateral ramules.

Known from three collections on Cape Arago (*MD 6353*, **TYPE:** *MD 4142* [Dudley Herbarium 306911], and *MD 6355*) in January. This alga was growing in association with *Bossea plumosa* in rather high (above LHLW) shallow tidepools.

This Oregon species is somewhat lower in stature, the intergenicula are distinctly broader in proportion, and they form a more closely jointed frond than Manza's type material of *J. pinnatifolius*. The frond of *J. delicatulus* overall is much more delicate.

BOSSEA Manza, 1937

Bossea plumosa Manza, 1937a:46; — Manza, 1940:303. *pl. 12, figs. 1-2*; — Smith, 1944:233. *pl. 51, fig. 1.*

Common throughout the range south of Cape Arago. *MD 2712* (Cape Blanco) is identical in all superficial characteristics with the type in the the University of California herbarium as number *545710.*

Bossea frondifera Manza, 1937b:562; — Manza, 1940:306. *pl. 14.*

Common on rocks between the LHLW and MLLW levels at Cape Arago. *MD 1848* from Sunset Bay is the same as the type in the University of California herbarium as number *545757.*

Bossea Orbigniana (Decaisne) Manza, 1937b:563.

Only three collections are known from Oregon; each different from the rest. *MD 4117*, collected at Middle Bay, seems to be similar to the University of California number *296059*, bearing the annotation, "type of Manza." In Gardner's notebooks under the number *2787, Amphiroa tuber-*

culata f. *Orbigniana* is recorded from Sunset Bay. This Gardner collection is similar to *MD 2725* from Oceanside (Cape Mears).

Differing from *B. Gardneri* in having two conceptacles on each surface of fertile intergenicula and in having these close together, or very near the midrib, and in the more slender nature of the less conspicuously dichotomous fronds. *B. Gardneri* has 3 — 6 conceptacles on the surfaces of the fertile intergenicula and the upper angles of the intergenicular wings are more rounded than in *B. Orbigniana*.

Bossea Gardneri Manza, 1937b:563; — Manza, 1940:306. *pl. 15.*

Two collections: one (*MD 2612*) from Cape Blanco in June; the other from Brookings in December (*MD 4177*). These are quite similar to specimens of *B. californica* in the University of California herbarium.

Bossea californica (Decaisne) Manza, 1937b: 561; — Manza, 1940:305; — Smith, 1944:233. *pl. 51, fig. 2.*

In Gardner's notebooks, under number *2717*, there is listed *Amphiroa tuberculata* f. *californica* from near the Cape Arago lighthouse. This specimen has not been seen.

Bossea corymbifera Manza, 1937b:562; — Manza, 1940:305. *pl. 13*; — Smith, 1944: 234. *pl. 52, fig. 3.*

Charlotte L. Doty 1895 (North Bay, July) and *MD 6354* (sloping wet tidepool shore, Sunset Bay, July) are finely branched, unusually flat and thin fronds that seem nearer this species than any other described by Manza. The North Bay collection is very much like some specimens of Manza's at the University of California, but still not like the type.

CALLIARTHRON Manza, 1937

Calliarthron regenerans Manza, 1937b:565; — Manza, 1940:269. *pl. 4, figs. 1–4.*

At Cape Arago and southward throughout the range. Other species have been collected in sterile condition or in forms that were not definitely identifiable.

MELOBESIA Lamouroux, 1812

Melobesia mediocris (Foslie) Setchell & Mason, 1943:95; — Smith, 1944:219. *pl. 49, fig. 1.*

Abundant on *Phyllospadix* at Sunset Bay (*MD 1840*) in July, probably throughout the range since it has been observed on its host elsewhere.

Melobesia marginata Setchell & Foslie, *in* Foslie, 1902:10; — Smith, 1944:219. *pl. 49, fig. 2*; *pl. 50, fig. 1.*

Observed throughout the range but identification confirmed by examination of sections in two cases only, on *Laurencia spectabilis* and *Botryoglossum Farlowianum* at South Bay in December (*MD 4102*) and on *Plocamium pacificum* at North Bay (*MD 4984*) in July.

LITHOTHAMNION Philippi, 1837

Lithothamnion conchatum Setchell & Foslie, *apud* Foslie, 1902:6; — Smith, 1944: 222. *pl. 50, fig. 2.*

Along with the next species sparingly throughout the range on species of *Calliarthron* and on *Corallina densa.*

Lithothamnion parcum Setchell & Foslie, *apud* Foslie, 1907b:14; — Smith, 1944: 223.

Throughout the range on *Calliarthron* and *Corallina.*

Lithothamnion lamellatum Setchell & Foslie, *apud* Foslie, 1903:4; — Smith, 1944: 222.

Throughout the range as far north as Boiler Bay (*MD 2646*) on rocks below MLLW.

Lithothamnion pacificum Foslie, 1906:10; — Smith, 1944:221. *pl. 49, fig. 3.*

Throughout the range tetrasporic in January (*MD 4154* and *4153*, South Bay) and also during the summer. A form smoother than usual was found on the shell of *Searlesia dira.*

Other *Lithothamnion*-like material collected and sectioned has proven to be either sterile or lacking tetraspores. One of these unidentifiable entities is very similar to *L. californicum*, and is to be found at least throughout the southern half of the range.

FOSLIELLA Howe, 1920

Fosliella dispar (Foslie) G. M. Smith, 1944:225. *pl. 50, fig. 6.*

Common on both species of *Ahnfeltia* in the Brookings area.

Other members of this genus have been collected on various uncalcified red algae but the specimens sectioned, with one exception, could not be identified with certainty because they were not tetrasporic. One collection (*MD 2184*, from lighthouse reef, Cape Arago) seems to be an undescribed species on *Phyllospadix.*

LITHOPHYLLUM Philippi, 1837

Lithophyllum neofarlowii Setchell & Mason, 1943:95; — Smith, 1944:228.

Common south of Cape Arago (*e.g.*, *MD 4155*, tetrasporic in January; *4164* and *4163*).

?Lithophyllum grumosum Foslie, 1909:20; — Smith, 1944:227.

Sterile or sexual material that seems to be this species has been collected several times at Cape Arago.

GRATELOUPIACEAE

GRATELOUPIA C. Agardh, 1822

Grateloupia californica Kylin, 1941:9. *pl. 1, figs. 1–2*; — Smith, 1944:239. *pl. 55, figs. 1–2.*

Throughout the range, with more northern forms tending to be smaller and more proliferous than the southern collections.

In high-lying tidepools there is a form (*MD 2628*, Seal Rocks) that may prove specifically distinct from *G. californica*. It is very proliferous, thick, slimy, and has a strong tendency to lose the red color that normally masks the chlorophylls.

Grateloupia maxima (Gardner) Kylin, 1941:10

Grateloupia Cutleriae forma *maxima* Gardner, 1911, *in* Collins *et al.*, Phyc. Bor.-Amer. fasc. E:124.

At the University of California there is a collection of this species by Gardner (*2687a*) labeled, "Sunset Beach south of Cape Arago." This is very similar to the material distributed in the Phyc. Bor.-Amer. as cited above. Two other collections from Oregon are also considered this species. One was made at Middle Bay (*O'Neal 351b*); the other was found cast ashore at Chetco Cove (*MD 6102a, 6102c*).

Grateloupia Setchellii Kylin, 1941:10. *pl. 1, fig. 4*; *text fig. 2d*; — Smith, 1944:240. *pl. 55, fig. 3.*

Thallus pinnately branched, 15 cm. tall and rarely 1 cm. broad, pinnules often pinnate at their bases; resoaked specimens up to 200 μ thick with cortex in such a section about 28 μ thick, of 1 to 2 cells the outermost of which is elongated vertically, the weakly developed medulla about 45 μ thick and of 3–5 filaments, with a layer of 2 or 3 larger subcortical cells between each about 25 μ thick; bright red when fresh and not as soft or slimy as usual in other Pacific Coast species; tetrasporangia scattered and broadly elliptical, about 35 x 28 μ, cruciately divided, superficial in the cortex but exceeding this inwardly; cystocarps and tetrasporangia borne principally on the lateral pinnules but also on the main axis.

Known in Oregon only from Otter Point (*MD 6173*, July) where it is common just beneath *Laminaria Sinclairii* where this latter appears (displaced from its normal habitat) on the vertical surfaces of large rocks protruding from the sand in exposed localities between MLLW and LLLW. Both tetrasporic and cystocarpic individuals were collected.

CRYPTONEMIA J. Agardh, 1842

KEY TO THE SPECIES OF *CRYPTONEMIA* TO BE FOUND ON THE OREGON COAST

1. Fertile fronds over 120 μ in thickness; medulla of 5–8 or more parallel filaments ..... **C. obovata**
1. Fertile fronds less than 120 μ in thickness; medulla of 2–5 loosely interwoven filaments 2
   2. Thalli small (up to 7 x 5 cm.), symmetrical, ovate, with a stipe-like base; medulla of 2–3 filaments (therefore very loose in structure) .... **C. ovalifolia**
   2. Thalli larger (up to 10 x 8 cm.), asymmetrical or obovate, no stipe-like base, never over 70 μ thick; medulla of 3–5 filaments (therefore rather dense in structure) ..... **C. borealis**

Cryptonemia obovata J. Agardh, 1876:681; — Kylin, 1925:19. *fig. 8a*; — Kylin, 1941:11. *pl. 3, fig. 8.*

On rocks between MLLW and LLLW at Otter Crest (*MD 6182*, sterile, July).

Cryptonemia ovalifolia Kylin, 1941: 11. *pl. 3, fig. 9*; — Smith, 1944:241. *pl. 54, figs. 2–3.*

Cystocarpic and male thalli (*MD 1993* and *O'Neal 262*) have been collected on the lateral walls of a large tidepool at South Bay in July. While small this material compares well with the isotype in the Dudley Herbarium (number *306388*).

Cryptonemia borealis Kylin, 1925:19. *figs. 8b–e, 9.*

For a number of years this species has been observed (and collected, *e.g., MD 2573*) growing on the same flat rock at the MLLW tide level in the entrance to a cave on Coos Head.

AEODES J. Agardh, 1876

Aeodes Gardneri Kylin, 1925:17. *fig. 7*; — Smith, 1944:242. *pl. 54, figs. 4–5.*

Frequently cast ashore and occasionally collected from rocks submerged in the larger tidepools on Cape Arago.

ZANARDINULA De Toni, 1936

Zanardinula Andersoniana (J. Agardh) Papenfuss, 1944:342.

Prionitis Andersoniana Eaton *ex* J. Agardh, 1876:159; — 1898, *in* Collins *et al.*, Phyc. Bor.-Amer. fasc. 9:448; — 1877, *in* Farlow *et al.*, Alg. Exsicc. Amer.-Bor. No. 24; — Smith, 1944:246. *pl. 57, fig. 3.*

Throughout the range about the bases of rocks buried in sand between the MLLW and LLLW levels. Forms such as the Phyc. Bor.-Amer. specimens cited are transitional toward the thin-bladed condition of some forms of *Z. lanceolata.*

Zanardinula Lyallii (Harvey) De Toni, 1936:7.

Prionitis Lyallii Harvey, 1862:173; — Smith, 1944:247. *pl. 56, fig. 3.*

Common between the LHLW and MLLW levels but growing higher where the rocks are continually moist. Often found almost completely filling tidepools at levels up to 10 feet above MLLW. Throughout the range in a multiplicity of forms.

Most of the Oregon material is of forms that have more linear, narrower branches than the form figured by Smith. When this species grows in high-lying tidepools it is often very brown in color and flaccid.

Zanardinula lanceolata (Harvey) De Toni, 1936:7.

Prionitis lanceolata Harvey, 1853:197. *pl. 27, fig. A*; — Smith, 1944: 246. *pl. 57, fig. 1.*

Common throughout the range.

Zanardinula filiformis (Kylin) Papenfuss, 1944: 342

Prionitis filiformis Smith, 1944:244. *pl. 56, fig. 1.*

Prionitis filiformis Kylin, 1941:13.

Prionitis angusta Setchell, 1899, *in* Collins *et al.*, Phyc. Bor.-Amer. fasc. A:24 (*non* Okamura).

Prionitis lanceolata β angusta Harvey, 1853:197.

PLATE 13, FIG. A

Thalli linear, up to 35 cm. tall, lower parts terete about 1 mm. in diameter, ultimate branchlets flattened but still very narrow and linear, usually less than 1.5 mm. broad but in short robust specimens occasionally up to 2.0 mm. broad; branching in upper portion of major branches appears irregularly dichotomous due to the elongation of lateral pinnules; pinnate marginal proliferations if present short (less than 3 mm. long); cystocarps present in the pinnules; thalli bright red, growing in more or less hemispherical tufts.

The two uppermost fronds show in Plate 13, Fig. A are of typical form; the lowermost is the broadest form and nearest approach in form to the next species.

Throughout the range at least south of Squaw Creek on MLLW to LLLW rocks. *MD 2295* (Dudley Herbarium *306913*), Squaw Island, was cystocarpic in July.

Without an authentic specimen that can be chosen as a lectotype, it cannot be established which form Harvey had in mind by his *β angusta*. From his description, "much more slender, forked, with few and nearly naked branches," it might very well be a variety of *Z. lanceolata* or *Z. Kylinii*.

Zanardinula Kylinii nom. nov.

Zanardinula linearis (Kylin) Papenfuss, 1944:342. (*nom. nud.*)
Prionitis linearis Smith, 1944:245. *pl. 56, fig. 2.* (*nom. nud.*)
Prionitis linearis Kylin, 1941:12. (*nom. nud.*)
Prionitis lanceolata Collins, Holden & Setchell, 1896, *in* Collins *et al.*, Phyc. Bor.-Amer. fasc. 4:199b.

PLATE 12, FIG. B

Thalli ubique lineares, minimum usque ad 11 cm. altitudine atque usque ad 1.5 mm. latitudine, stipite, aut stipite cum dichotomia prima, plus quam dimidium altitudinis totius efficiente; pars solum inferior stipitis erecti non-ramosi teres, reliquus stipes et prima vel duae dichotomiae compressae, reliquae duae tresve dichotomiae manifeste complanatae; dichotomiae regulares ad aut prope apicem crescentem videntur; proliferationes laterales, breves, simplices dichotomaeve, interdum in lateribus dichotomiarum inferiorum, raro in stipite adsunt, hae rarius conspicuae aut plus quam 5 mm. longitudine sunt.

Thalli linear throughout, up to 11 cm. tall and up to 1.5 mm. broad, over half the height in stipe, or stipe and the first dichotomy; only the lower part of the erect unbranched stipe terete, the remainder of the stipe and the first one or two dichotomies compressed, the remaining two or three dichotomies flattened; the regular dichotomies appear at or near the growing apex; short simple or dichotomous lateral proliferations may be present along the sides of the lower dichotomies or rarely on the stipe; these are only rarely conspicuous or over 5 mm. long.

TYPE: *Charlotte L. Doty 2440* (Dudley Herbarium *307369*), forming hemispherical tufts between the MLLW and LLLW tide levels at Sunset Bay, Cape Arago, Coos County, Oregon, July 30, 1940. **COTYPE**: *MD 6341*, collected by John Merkle at Three Rox near Neskowin, Tillamook County, in January.

Oregon specimens are, for the most part, more slender and have fewer pinnate branchlets than the *Phycotheca* specimens cited, but seem to represent the same species. This species seems to differ from Dawson's (1944: 283. *pl. 67, fig. 2*) *Prionitis mexicana* in being coarser and in having fewer long pinnate branches.

This entity though long separated from other species of this genus has never been legitimately described. Such situations as this are embarrassing for all parties concerned, when following the rules of nomenclature dictates the introduction of a new name, as is necessary in this instance.

LOBOCOLAX Howe, 1914

Lobocolax deformans Howe, 1914:91; — Smith, 1944:248. *pl. 57, fig. 4.*

Possibly throughout the range of the host, *Prionitis lanceolata*, but no certainly identifiable fertile material known from Oregon.

CALLYMENIACEAE

CALLOPHYLLIS Kützing, 1843

Callophyllis flabellulata Harvey, 1862:171; — Kylin, 1925:34. *fig. 16* (type specimen figured).
Callophyllis marginifructa Setchell, 1923b:398; — Smith, 1944:250. *figs. 3–4.*
Callophyllis crassifolia Setchell, 1923b:398; — Smith, 1944:250.

At all stations below MLLW usually washed in fruiting in the summer and not seen during the winter months.

C. flabellulata is supposed to differ from *C. marginifructa*, which has the cystocarps all along the margins, in having the cystocarps restricted to the terminal segments. From the comparison of many specimens at the Universities of Oregon and California, and at Stanford University, it is concluded that in thicker forms growing in deep water the cystocarps are produced first on the terminal branchlets and later, or from the first in narrow and thin forms, all along the margins. Kylin (1941:16) expresses doubt as to any constant difference between *C. flabellulata* and *C. marginifructa*. *C. crassifolia* as collected in quantity in the Monterey region of California seems to be but a very thick form of the above species. The types, as figured by Kylin, of *C. flabellulata*, and as deposited at the University of California, of *C. marginifructa* and *C. crassifolia*, fit well into the gamut of variation displayed by the available Oregon and other west coast specimens.

Callophyllis megalocarpa Setchell & Swezy, *apud* Setchell, 1923b:401; — Smith, 1944:251. *pl. 59, fig. 1.*

Throughout the range at the bottoms of tidepools, and cast ashore in small numbers during the summer months (*e.g.*, *MD 2396*, Squaw Island, cystocarpic).

While the Oregon material is of lower stature (up to 12 cm. tall) and seems to be less harsh or crisp, it compares well with young specimens from the Monterey Peninsula and elsewhere.

Callophyllis crenulata Setchell, 1923b:400; — Smith, 1944:250. *pl. 58, fig. 1.*

Common south of Cape Arago and probably throughout the range, washed in during the summer (often as an epiphyte).

Material collected at Cape Blanco (*MD 2517a*, in July) and a few miles south of the mouth of the Chetco River (*MD 6104a*) looks very much like the type at the University of California.

Callophyllis heanophylla Setchell, 1923b:401; — Kylin, 1925:34. *fig. 17.*

One collection (*MD 4975*) North Bay, cystocarpic in July.

This species is distinct from other similarly flabellately branched species in having rather small cystocarps (usually 0.5 mm. in diameter and probably never over 0.75 mm.) scattered over the surface. The thalli are usually less than 7 cm. tall and none are over 12 cm. tall.

Callophyllis violacea J. Agardh, 1884:34; — Kylin, 1941:16. *pl. 5, fig. 13.*

Growing with and below *Lessoniopsis* at MLLW to at least as low as LLLW in characteristic tufts on crustose corallines and probably directly on the rock substratum. *MD 2530a*, Cape Blanco, is cystocarpic; the northernmost Oregon collection (*MD 2636*) is from Boiler Bay; both were collected in July.

Callophyllis pinnata Setchell & Swezy, *apud* Setchell, 1923b:400; — Smith, 1944:251. *pl. 58, fig. 2.*

Common at least south from Cape Arago. Only washed in material has been obtained from Oregon, but on the Monterey Peninsula, California, it is rather common between the MLLW and LLLW levels and lower.

Resembling *C. obtusifolia*, and usually identified with that species, however, it differs in that it is a much broader often digitately branched alga and is larger in all respects. Only the older thalli have the characteristic stalked pinnules on the lower margins. Sometimes the pinnules may be very thin and arise from a very much darkened and thickened fragment of the parent blade. Next to the *flabellulata*-group this is the form most frequently collected.

There are four collections known to the author (Sanborn collection from Cape Arago in the University of California herbarium; *O'Neal 208*, North Bay; *Eustice and Doty 2100*, washed in at Lighthouse Beach; and *C. L. Doty 2516*, Cape Blanco) which seem to be distinct from *C. pinnata* because of their extreme pinnation. However, since they are not fruiting (*i.e.*, not cystocarpic) and the pinnules clearly arise from an eroded parent blade, identification of them is uncertain. Perhaps it is only an unusually proliferous form of this species.

Callophyllis edentata Kylin, 1925:34. *fig. 18.*

Locally abundant in moderate to large-sized tidepools on Cape Arago.

Callophyllis oregona sp. nov.

PLATE 11, FIG. A

Thallus usque ad 12 cm. altitudine, alterne aut dichotome irregulariter ramosus; rami 5 ad 8 mm. latitudine, divaricati, marginibus levibus; cystocarpi admodum intra

margines partium frondis mediarum vel latissimarum primum enascentes; ostiola 2 vel 3 (1 ad 5) ad superficiem laminae marginisque perpendiculariter disposita.

Thallus up to 12 cm. tall, irregularly alternately or appearing at times dichotomously branched; branches 5 — 8 mm. broad, divaricate, margins smooth; tips divided into a few (2 — 4) short fine blunt processes; cystocarps almost all with their 2 or 3 (1 — 5) ostioles directed at right angles to the surface of the blade and just within the margins themselves (48 out of first 50 counted), appearing along the margins in the middle or broadest portion of the frond.

Known only from material washed ashore at North Bay (*MD 5063*, July) and at Brookings (*O'Neal 404* and the **TYPE:** *MD 2594* [Dudley Herbarium *306925*], both cystocarpic, and collected on June 24, 1941).

PUGETIA Kylin, 1925

Pugetia fragilissima Kylin, 1925:30. *fig. 14.*
Pugetia firma Kylin, 1941:15. *pl. 4, fig. 12*; — Smith, 1944:254. *pl. 60, fig. 1.*

Throughout the range between MLLW and LLLW levels and probably lower. Pendant from overhanging rocks or on shaded sides of vertical rocks.

P. fragilissima and *P. firma* have been considered distinct species because of thickness, size of blades, and the number of cortical cells. The same holds for material collected on the Monterey Peninsula in California. Some thin specimens agreeing well with the description of *P. fragilissima* and other thick (up to 1.5 mm.) specimens agreeing with the description of *P. firma*; still other specimens are intermediate between the two. The specimens collected in Oregon intergrade so completely in these respects that the two cannot be considered distinct.

GIGARTINALES

NEMASTOMACEAE

SCHIZYMENIA J. Agardh, 1851

Schizymenia pacifica Kylin, 1932:10; — Smith, 1944:258. *pl. 60, fig. 4*; *pl. 61, fig. 1*; — Collins *et al.*, 1897, Phyc. Bor.-Amer. fasc. 8:395.
Turnerella pacifica Kylin, 1925:21. *fig. 11.*
Sarcophyllis californica Setchell & Gardner, 1903:354 (*non* J. Agardh).

Throughout the range below the MLLW level.

Although the blades of this alga are often irregularly split, they differ from those of *Dilsea californica* (see page 165) in not being divided into linear curved segments. Our species of *Schizymenia* likewise differs from *Dilsea* in having regularly present an abundance of gland cells (8–15 x 20–60μ), a small ostiole over each cystocarp, in being as a rule slimy to the touch when fresh, in lacking a subcortical layer of large granular cells, and in usually drying light colored on herbarium sheets.

SOLERIACEAE

OPUNTIELLA Kylin, 1925

Opuntiella californica (Farlow) Kylin, 1925:23. *fig. 11*; — Smith, 1944:262. *pl. 61, fig. 2.*

Throughout the range on rocks in well-aerated water; between MLLW and LLLW levels.

AGARDHIELLA Schmitz, 1896

Though the alga *Agardhiella Coulteri* is said to be common along the Pacific Coast from British Columbia to southern California, no specimens have been found along the Oregon Coast (nor are there specimens in the University of California herbarium from there) though a continued painstaking search has been made for it. Since this alga does seem to be present in Puget Sound the range should be given as Puget Sound *and* central California.

PLOCAMIACEAE

PLOCAMIUM Lamouroux, 1813

Plocamium oregonum sp. nov.

PLATE 14, FIG. B

Thalli usque ad 13 cm. altitudine obscuro-rubri, nisi ad cacumina; axes primarii complanati, 1 mm. vel minus latitudine, rami primarii supra robustores facti quam axis primarius infra; ramuli ad apicem robustiores facti ut partes frondium inferiores admodum macrae saepe videantur; rami primarii ad basim longitudine aucti.

Thalli up to 13 cm. tall, dull red in color except at the tips; main axes flattened, 1 mm. or less broad; major branches in upper part of thallus corymbose, of greater diameter than lower portion of the main axis; secondary branches increasing in size toward the apex of the thallus; the lower parts of major branches often appearing barren, because of the smaller branchlets there.

TYPE: *MD 6151* (Dudley Herbarium *306916*), in hemispherical tufts between MLLW and LLLW, Harris State Park, Brookings, Curry County, Oregon, July 6, 1944. *F. P. Sipe 613*, just south of Cape Perpetua, Lincoln County, Oregon, July.

The following specimens in the *P. pacificum* folder in the University of California herbarium may be assigned to this species: *651501*, "abundant in tufts on stones in lower littoral pools"; *276451* (and in the Dudley Herbarium *306914*) (*Gardner 3047*), Tomales Bay, California; *651633* (and in the Dudley Herbarium *306915*) (*Gardner 7837*), *276358*, *276349*, *276383* (*H. E. Parks*) Trinidad, California; *276502* (*Gardner 2683*) Sunset Bay; *266338* (*Mrs. R. W. Summers 1543*) Yaquina. In addition the author has two collections, *John Queen 49* and *MD 2406*, both from Squaw Island.

The type has been compared with a specimen of *P. oviforme* Okamura deposited by Okamura in the University of California herbarium (*418240*)

and found to be quite different. As compared with other Pacific Coast species of *Plocamium* it is taller than either *P. violaceum* or *P. tenue* and more slender, and less densely branched than *P. pacificum*.

Plocamium tenue Kylin, 1925:43. *figs. 24c-d.*

On vertical rocks between MLLW and HHLW at South Bay (*MD 4104*) in January, and along the north shore of Chetco Cove (*MD 6110*) in July.

To be distinguished from *P. violaceum* by the abundance of branching, the smaller less conspicuous simple branches less than 4 mm. in length, and by the smaller diameter of the main axes which are rarely over 0.5 mm. in diameter. Usually it grows in rather dense stands whereas *P. violaceum* is almost always in isolated tufts. *P. violaceum* usually has a simple erect axis, or is branched right at the base but without long lateral branchlets. The simple branchlets of *P. violaceum* are usually over 4 mm. long at maturity, and the main axis generally becomes 0.75 to 1.0 mm. in diameter at maturity.

Plocamium violaceum Farlow, 1877:240; — Smith, 1944:264. *pl. 62, fig. 2.*

Between MLLW and HHLW on Cape Arago (*e.g., C. L. Doty 2450*).

The Oregon specimens referred to this species are short in stature and finely branched and may more truly be a form of *P. tenue*.

Plocamium pacificum Kylin, 1925:42. *fig. 24b*; — Smith, 1944:264 *pl. 62, fig. 1.*

Throughout the range between MLLW and LLLW.

PLOCAMIOCOLAX Setchell, 1923

Plocamiocolax pulvinata Setchell, 1923a:396; — Smith, 1944:265. *pl. 62, fig. 3.*

This species is recorded in Gardner's notes under number *2694* as from Sunset Beach, Cape Arago.

GRACILARIACEAE

GRACILARIA Greville, 1830

Gracilaria Sjöstedtii Kylin, 1930a:55; — Smith, 1944:267. *pl. 63, fig. 4.*

Throughout the range on sand-covered rocks between MLLW and LLLW.

No attempt has been made to distinguish specimens that might be referred to *G. confervoides* instead of the present species. However specimens collected at Fossil Point in Coos Bay (*MD 1934*) have a cortex of 5 to 6 cells in thickness and lack filaments between the cystocarp wall and the carposporophytic tissues.

GRACILARIOPHILA Setchell & Wilson, *apud* Wilson, 1910

Gracilariophila oryzoides Setchell & Wilson, *apud* Wilson, 1910:81. *pl. 12–13*; — Smith, 1944:268. *pl. 63, fig. 1.*

Parasitic on *Gracilaria Sjöstedtii* in Coos Bay and at Lighthouse Beach.

PHYLLOPHORACEAE

AHNFELTIA Fries, 1835

Ahnfeltia concinna J. Agardh, 1847:12; — Setchell & Gardner, 1903:305.
Ahnfeltia Gigartinoides J. Agardh, 1847:12; — Smith, 1944:272. *pl. 64, fig. 1.*

Locally abundant throughout the range between MLLW and LLLW, usually on boulders partially buried in sand. Nemathecoid swellings are present on the specimens collected during the summer.

Setchell & Gardner say, "We have united under this name the *A. concinna* and the *A. Gigartinoides* of J. G. Agardh." Since they are the first authors to treat one of them as a definite synonym of the other they have the right to choose either, since these two species were published at the same time. Therefore, *A. concinna* must be used in preference to *A. Gigartinoides* unless these are treated as two different entities.

Ahnfeltia plicata (Hudson) Fries, 1835:310; — Smith, 1944:271. *pl. 64, figs. 2–3.*

Common throughout the range on rocks between MLLW and LLLW and often abundant in tidepools, especially those that are crack-like in nature and partially sand-filled. The specimens collected during the summer have the characteristic nemathecoid swellings of this genus.

GYMNOGONGRUS Martius, 1833

Gymnogongrus linearis (Turner) J. Agardh, 1851:325; — Smith, 1944:274. *pl. 65, fig. 3.*

Throughout the range south of Cape Perpetua, where it was collected by F. P. Sipe (*13, 19*) between the MLLW and LLLW levels on rocks.

Gymnogongrus leptophyllus J. Agardh, 1876:211; — Smith, 1944:273. *pl. 65, fig. 1.*

Cast ashore at Lighthouse Beach in July (*MD 5011*, cystocarpic) and on rocks of the old jetty in Coos Bay in June (*MD 4542*).

PETROGLOSSUM Hollenberg, 1939

Petroglossum pacificum Hollenberg, 1943:573. *figs. 1–6.*

Thallus 100–120 μ thick, 3–5 mm. broad, and up to 3 cm. tall, bright red; arising from a thin discoidal holdfast by means of a short cylindrical stipe (up to 1.5 mm. long and 0.3 mm. broad) that bears distichous opposite bladelets in a few pairs, these in turn stipitate; blade irregularly dichotomous or simple, margin smooth but sinuous; tip rounded; cortex of one or two layers of small cells a little lower than tall in cross section and averaging about 10 μ in the greatest diameter, sub-cortex of one or two larger cells; medulla of large cells hexagonal in surface view and irregularly elliptical in cross or longitudinal section and about 70–80 μ in diameter; no veins or ribs.

MD 4996, North Bay in July, and *MD 2599*, Brookings in June, both sterile and the latter on the vertical sides of HHLW rocks and on small barnacles (*Balanus sp.*) overhung by larger algae.

This material differs from Hollenberg's description in being broader, in having opposite pinnules arising from the cylindrical stipe, and in the slightly larger size of the outer cortical cells.

STENOGRAMME Harvey, 1841

Stenogramme californica Harvey, 1841:408; — Smith, 1944:276. *pl. 64, fig. 4*; *pl. 65, fig. 4.*

Throughout the range at MLLW level and lower.

GIGARTINACEAE

GIGARTINA Stackhouse, 1809

Gigartina mamillosa (Goodenough & Woodward) J. Agardh, 1851:278; — Setchell & Gardner, 1933:285.

Reported in Oregon from Seal Rocks by Setchell & Gardner (*A. R. Sweetser 35*, June). F. P. Sipe recently collected material at this same locality that looks very much like the Sweetser collection. This entity seems to occur elsewhere along the Oregon coast and south into California. Whether it is specifically distinct from *G. papillata* and *G. cristata* is debatable. This species along with *G. papillata* dominates an irregular zone between the HHLW and LLHW tide levels; immediately beneath the zone dominated by *Gloiopeltis furcata.*

Gigartina papillata (C. Agardh) J. Agardh, 1846: *pl. 19*; — Smith, 1944:283. *pl. 70, fig. 2.*

Gigartina papillata var. *subsimplex* Setchell, 1898, *in* Collins *et al.*, Phyc. Bor.-Amer. fasc. 9:425.

Gigartina obovata J. Agardh, 1899:25; — Setchell & Gardner, 1933:268. *pl. 62.*

Throughout the range in scattered tufts between HHLW and LHHW tide levels. Some of the broader forms of this species are among the highest-growing of all species of *Gigartina*. The broad **G. papillata** var. **obovata** (J. Agardh) com. nov. (syn. *G. obovata* J. Agardh. Anal. Alg., 1899:25) is in places the dominant algal cover lower than typical for the species in the Brookings region (*e.g., MD 6124*) where it is best developed in the lower part of the *Fucus*-zone of distribution.

Gigartina cristata (Setchell) Setchell & Gardner, 1933:290. *pl. 64*; — Smith, 1944: 284. *pl. 69, fig. 2.*

This species is common at Brookings, Cape Blanco, Cape Arago, and on the old jetty within Coos Bay (*e.g., MD 2708*). Because of its habit of growth on the tops of boulders (2–3 feet in diameter) it is difficult to estimate its position in the vertical scale but it seems rather restricted about mean sea level, or in the uppermost part of the LHLW to HHLW zone.

Gigartina volans (C. Agardh) J. Agardh, 1846. *pl. 18*; — Smith, 1944:282. *pl. 70, fig. 1.*

The Gardner collection number *6536* mentioned by Setchell & Gardner (1933:280) represents a form that is abundant in the sand about the rocks at the mouth of the Carmel River, Monterey County, California.

It seems to arise as the result of sanding-in around the bases of thalli that are typical in appearance when the process begins but which elongate and expand as the thallus is gradually buried. Such forms have been collected in Oregon. They are common at a number of localities along the central coast of Oregon. This species has also been found at Cannon Beach (about the south inshore side of the high rocks there), Clatsop County, and Seal Rocks (*O'Neal 430*), Lincoln County, in the northern part of the state.

Gigartina Harveyana (Kützing) Setchell & Gardner, 1933:276; — Smith, 1944:282. *pl. 67, fig. 2.*

In color, texture and form the Oregon specimens are in every way like those collected on the Monterey Peninsula. They (*MD 4523*) were growing in the sand on a tidepool bottom near the old jetty in Coos Bay, in June.

Gigartina californica J. Agardh, 1899:39; — Smith, 1944:280. *pl. 67, fig. 1.*

Sparse in the Cape Arago and Coos Bay regions but becoming common further south at Brookings; growing on rocks between MLLW and LLLW and lower.

Gigartina exasperata Harvey & Bailey, 1851:371; — Setchell & Gardner, 1933:275.

Throughout the range below MLLW levels.

This species differs from *G. Binghamiae* in being thicker and in having the surface covered with acuminate papillae of different sizes when young. The papillae are often bifurcate or bear more than one cystocarp, and the cystocarps are not nearly as sessile as in *G. Binghamiae*. The color is dark reddish to light brownish red.

Gigartina Binghamiae J. Agardh, 1899:33; — Setchell & Gardner, 1933:277. *pl. 55.*

Common in the Coos Bay region below the MLLW level. Also brought up once in an otter trawl from 25 fathoms, 8 miles off the Coos Bay Bar in November (*H. C. Luce 9*, collected by Clarence Hubbard, cystocarpic).

This species is to be distinguished from other species in the section *Cheilogigartina* by its light red color (which is not at all brownish or orange, as in *G. corymbifera* or *G. Harveyana*), by its thin fronds, and by the way the large solitary cystocarps terminate rather long papillae along the frond margins and their relatively sessile sparse arrangement on the surface of the blades.

Gigartina canaliculata Harvey, 1841:490; — Smith, 1944:278. *pl. 69, fig. 3.*

Common on LHLW to MLLW rocks near the lighthouse reef on Cape Arago (*MD 2187*, June); at North Bay (*MD 2681*, July); and at South Bay (*MD 6338*, January); growing intermingled with *Odonthalia floccosa* and *Gelidium Coulteri.*

RHODOGLOSSUM J. Agardh, 1876

Rhodoglossum affine (Harvey) Kylin, 1928:49; — Smith, 1944:287. *pl. 71, fig. 2.*

Found at Cape Blanco (*O'Neal 419*); outer reef at Squaw Island (*MD*

2394, collected by O. R. O'Neal, and *MD 2302*); and Coos Bay (*Wayne Wells 37*). In the LHLW to MLLW zone.

While most of the material is depauperate and juvenile the collection from Squaw Island by O'Neal is cystocarpic. This is the northern limit for the species as known at present.

IRIDOPHYCUS Setchell & Gardner, 1936

Iridophycus flaccidum Setchell & Gardner, 1937:171; — Smith, 1944:288. *pl. 72, fig. 2.*

Probably throughout the range, but definitely known only from Cape Arago southward. This is one of the dominant species of the HHLW to LHLW zone. Fertile and abundant throughout the summer and fall months, but scarce in winter, though a few mature specimens may be found then.

Iridophycus splendens Setchell & Gardner, 1937:170; — Smith, 1944:289. *pl. 72, fig. 1.*

Throughout the range between LHLW and MLLW levels. This alga is one of the dominant and characteristic species of this zone.

Iridophycus lineare Setchell & Gardner, 1937:171; — Smith, 1944: 290. *pl. 72, fig. 3.*

Throughout the range south of Cape Mears (*MD 2725*); most abundant at Otter Point (*MD 6228*).

When exposed by recession of the tide the blades of this alga, when growing in characteristic thick clumps, tend to form piles of blades which stand close together like the leaves of a book. In such clumps the fruiting may be conspicuously marginal. In clumps which are not so dense the characteristic ruffling of the margins of the blades is less apparent or may be absent entirely.

Iridophycus oregonum sp. nov.

PLATE 11, FIG. C

Thallus 2 ad 7 cm. latitudine et usque ad 25 cm. altitudine, plures proliferationes laterales praebens aut saltem partem superiorem irregulariter furcatam habens; stipes levis; apophysis plana, levis, late cuneata, venis praedita; medulla e filamentis tenuibus magna ex parte circa 5 micra diametro constans; cortex circa 80 micra crassitudine, tetrasporangiales minus quam 0.5 mm. diametro; tetrasporangia 25 ad 40 per 55 ad 70 micra, cruciata.

Thallus 2–7 cm. broad and up to 25 cm. tall; dark purplish when dry, less than 1 mm. thick; with several lateral proliferations or at least with the upper portion irregularly furcate; stipe smooth, terete, 0.75 mm. in diameter and up to 2 mm. long; apophysis plane, with a smooth margin, broadly cuneate or rounded, with no veins; medulla composed of slender filaments usually about 5 μ in diameter and never over 9 μ, except for the occasional stellate cells and larger cells that give rise to the tetrasporangial sori; cortex about 80 μ in thickness, of about 5 or 6 globose cells less than 10 μ in diameter and lying in widely separated vertical columns, the outer three cortical cells usually elongated perpendicular to the blade surface,

the innermost often elongated parallel to the thallus surface by processes that may appear as an equatorial swelling; tetrasporangial sori less than 0.5 mm. in diameter, the first formed within the apex of the blade, later-formed sori towards the base, the last-formed produced in the upper portion of the apophysis; tetrasporangia arising to either side of the axial filaments from large irregularly shaped cells up to 25 μ in diameter, tetrasporangia 25–40 x 55–70 μ and cruciate for the most part but often dividing quite irregularly.

TYPE: *MD 4056* (Dudley Herbarium *306918*), collected at Brookings, Oregon, on boulders in a tidepool between HHLW and LLHW, December 16, 1941. Only tetrasporic material was obtained.

At first glance this material seems identifiable with *Iridophycus sinicola* Setchell & Gardner. It differs from the type of that species at the University of California and from isotypes in the Dudley Herbarium, in having a greater number of narrower divisions, and in the less conspicuous more quickly broadened apophysis, as well as in the general aspect of the frond. From *I. heterocarpum* this species differs in having a much thinner cortex, in having longer, larger, and less-branched medullary cells, in the thinner frond, in the branching, and in the larger tetrasporangia.

Iridophycus heterocarpum (Postels & Ruprecht) Setchell & Gardner, 1937:170; — Smith, 1944:291. *pl. 73, fig. 3.*

Throughout the range.

Iridophycus coriaceum Setchell & Gardner, 1937:170; — Smith, 1944:290. *pl. 71, fig. 4.*

Throughout the range in exposed situations between MLLW and LLLW levels or lower. Specimens collected below the MLLW level are typical; specimens occasionally collected at higher levels are atypical, and may be found as high as HHLW levels in much exposed situations.

Iridophycus parvulum (Kjellman) Setchell & Gardner, 1937:170; — Collins *et al.*, 1902, Phyc. Bor.-Amer. fasc. 19:930.

On the sunny sides of huge boulders along with *Endocladia* in the LLHW to HHLW zone at Harris State Park (*MD 6155*), cystocarpic and tetrasporic in July.

Distinguished from other Oregon species of this genus by the brownish color, by the thick and leathery texture when fresh, by the small size (under 8 cm. broad by 10 cm. tall), by the suddenly broadened (to as broad as cordate) base, by the furcate or proliferous upper margin, and by the close often confluent tetrasporangial sori. This species differs from *I. heterocarpum* in the smaller cystocarps (in dried material almost entirely under 1.5 mm. in diameter) that are of more uniform size, with the oldest nearest the upper margin of the frond. The short stipe that is immediately cuneate, broadening into the thickened and often radiately veined but indefinitely limited apophysis, serves as an aid in distinguishing this entity from small forms of *I. coriaceum.*

Iridophycus fulgens Setchell & Gardner, 1937:173.

There are several collections in western herbaria from the Cape Arago region, but their position in reference to tide level is not known.

Iridophycus Whidbeyanum Setchell & Gardner, 1937:172.

There are two specimens (*O'Neal 421, 413*) collected from beach wash at Cape Blanco in June. Although these specimens have the thickness of *I. coriaceum* they have the form and structure described for *I. Whidbeyanum*.

Iridophycus cordatum (Turner) Setchell & Gardner, 1937:170.

Collected once (*O'Neal 415*) washed ashore at Cape Blanco in June.

Iridophycus sanguineum Setchell & Gardner, 1937:172; — Smith, 1944:289.

Known in Oregon from Lighthouse Beach by one collection in the University of California herbarium and from several of O'Neal's collections at Cape Blanco (*e.g., 366*).

ERYTHROPHYLLUM J. Agardh, 1871

Erythrophyllum Delesserioides J. Agardh, 1872:10; — Smith, 1944:292. *pl. 73, fig. 4.*

Throughout the range on shady rocks between the MLLW and LLLW levels.

Erythrophyllum splendens sp. nov.

PLATE 14, FIG. A

Thallus e laminis pinnatis ex axe rhizomaticoideo orientibus compositus, axe hapteron discoideum, fortasse vestigium thalli iuvenilis, habente; thallus nitido-ruber, lineari-lanceolatus, in basi rotundatus, in margine denticulatus, in omnibus praeter lamellas maximae iuveniles costas subnigras prominentes atque fere percurrentes habens, venulae laterales nullae.

Thallus up to 30 cm. tall; of pinnate blades 1–3 cm. broad, arising from a rhizome-like axis that itself has a discoidal holdfast, perhaps the remnant of the juvenile thallus; clear bright red (about Deep Rose Pink and darker to about Bordeaux through the Eugenia Red series of Ridgway when pressed and dried quickly on herbarium sheets), with a prominent and nearly percurrent blackish midrib in all but the youngest bladelets, with no veins from the midrib; bladelets linear lanceolate, rounded at the base, denticulate on the margin.

TYPE: *C. L. Doty 1951* (Dudley Herbarium *306922*), washed ashore at Sunset Bay, Cape Arago, Coos County, Oregon, July 11, 1940. **CO-TYPE:** *MD 2758* (Dudley Herbarium *206921*), found cast ashore in August at Sunset Bay.

Juvenile thalli are not markedly different from those of *E. Delesserioides*. Mature thalli of *E. splendens* differ in the shape of blades, lack of lateral veins from the midribs, and in the color, as well as by the pinnate nature of the mature frond. In cross section the cortex is thinner and of lower cells fewer in number than in *E. Delesserioides* and the medulla is

less dense; though the whole frond may be just as thick as the frond of *E. Delesserioides* of the same size.

RHODYMENIALES

RHODYMENIACEAE

RHODYMENIA Greville, 1830

Rhodymenia palmata var. **mollis** Setchell & Gardner, 1903:315; — Smith, 1944:301.

Most frequently found in tidepools partially filled with sand and between the MLLW and LLLW levels; Rogue River Reef, Cape Blanco, Cape Arago, and Boiler Bay. Tetrasporic material was collected in December (*MD 2550*) at Lighthouse Beach.

Rhodymenia pertusa (Postels & Ruprecht) J. Agardh, 1851:376.

There are two stations, one at Squaw Island (*MD 2289, 2651, O'Neal 485*) and the other along the north shore of Sunset Bay (*MD 4582*), where this species is always to be found in narrow or shaded crevices in the MLLW to LLLW zone.

Rhodymenia pacifica Kylin, 1931:21. *pl. 9, fig. 21*; — Smith, 1944:301. *pl. 76, fig. 1.*

Common at most stations from Cape Arago southward, growing between MLLW and LLLW tide levels.

Rhodymenia californica Kylin, 1931:21. *pl. 9, fig. 22*; — Smith, 1944:300. *pl. 74, fig. 2.*

Throughout the range south from Cape Arago, at about the same levels as *R. pacifica.*

FAUCHEA Montagne, 1846

Fauchea laciniata J. Agardh, 1884:40; — Kylin, 1931:9. *pl. 2, fig. 3* (figure of type specimen).

Fauchea media Kylin, 1941:27. *pl. 10, fig. 24*; — Smith, 1944:295. *pl. 73, fig. 1.*

non Fauchea laciniata Setchell & Gardner, 1903:313 (which is *fide* Kylin, 1925:39, *F. Fryeana*).

non Fauchea laciniata Setchell, 1901:124 (which is some species of *Callophyllis, fide* Smith, 1944:296).

Washed in and on LLLW rocks at North Bay in late July, both cystocarpic and tetrasporic.

Study of all herbarium material available of this genus shows that there are neither qualitative nor any non-intergrading quantitative differences between the specimens of *Fauchea* with the cystocarps spread over the surfaces of the frond. For this reason *F. media* is placed as a synonym of *F. laciniata.* The type of *F. laciniata*, as figured by Kylin, is perhaps an extremely laciniate form but no more than that. *F. Fryeana*, the northwest Pacific species with marginal cystocarps, seems to have a similar gamut of marginal variations. In none of the collections of *Fauchea* seen have there been detected any of the water-markings often so prominent in *Fryeella Gardneri.* While the tetrasporangial thalli remain reddish throughout, the

cystocarpic thalli when mature become thickened (1 mm.) and cartilaginous. As they further mature or begin to disintegrate they become still thicker, soft, translucent, and with a blue cast below. The surface becomes more or less papillose or roughened.

FRYEELLA Kylin, 1931

Fryeella Gardneri (Setchell) Kylin, 1931:16.
Fauchea Gardneri Setchell, 1901:125; — Setchell & Gardner, 1903:313. *pl. 19, fig. 30.*
Rhodymenia Gardneri (Setchell) Kylin, 1925:41. *figs. 22a–b.*

PLATE 12, FIG. A

Specimens washed ashore at Lighthouse Beach in late July (*MD 5018*, both tetrasporic and cystocarpic) look very much like the type in the University of California herbarium. Another tetrasporic collection was made in July by *O'Neal*, number *442*, at North Bay.

This species is readily distinguished in the field from the species of *Fauchea* and *Callophyllis* by growth lines resembling watermarks across each of the upper segments of the fronds. As in *Fauchea* the thalli become thick at maturity but are without the blue cast.

HALOSACCION Kützing, 1843

Halosaccion glandiforme (Gmelin) Ruprecht, 1851:279. *pl. 16*; — Smith, 1944:298. *pl. 73, figs. 6–7.*

Throughout the range on rocks between the LHLW and MLLW levels; growing intermingled with *Rhodomela larix* and *Gigartina canaliculata*. This appears to be a summer annual and it is very unusual to find it in winter months in a mature condition, though a few very ragged large specimens can be found then.

CERAMIALES

CERAMIACEAE

CERAMIUM Roth, 1797

KEY TO THE SPECIES OF *CERAMIUM* OCCURRING IN OREGON

1. Cortication complete everywhere except for a line on the internodes; tetraspores not protruding at maturity except during liberation 4
1. Cortication incomplete; tetraspores emergent, if not protruding, even before maturity 2
2. Saxicolous; violet; tetraspores immersed .....**C. washingtoniense**
2. Epiphytic or saxicolous; reddish; tetraspores protruding 3
3. Saxicolous (or on wood); uncorticated areas proportionally longer below ..... **C. Gardneri**
3. Epiphytic; uncorticated areas proportionally shorter below, until basal branches often almost completely corticated .....**C. californicum**
4. Epiphytic; transverse bands inconspicuous except at the apex ..... **C. codicola**
4. Saxicolous; transverse bands conspicuous 5

5. Blackish; without short proliferous branchlets below; corticating cells in longitudinal rows; with gland cells at the nodes .....**C. Eatonianum**

5. Red or violet; with short proliferous branchlets below; corticating cells irregularly arranged; without gland cells at the nodes .....**C. pacificum**

Ceramium Eatonianum (Farlow) De Toni, 1903:1493; — Smith, 1944:327. *pl. 84, figs. 3–4.*
Ceramium zebrinum J. Agardh, 1894:37.
Centroceras oregonense J. Agardh, 1876:107.

Common throughout the range south of Coos Bay; saxicolous, usually between HHLW and LHLW, but occasionally lower. The type, collected by Elihu Hall in Oregon in 1871, was probably from the northernmost part of the coast, *i.e.*, Clatsop County.

Ceramium codicola J. Agardh, 1894:23; — Smith, 1944:326. *pl. 84, fig. 1.*

Throughout the range on its host *Codium fragile*. Tetrasporic material (*MD 2317*) has been found in July.

The tips in this species are often straight and long, *i.e.*, not cheliform. Usually at each fertile node the tetraspores appear in two transverse irregular rows; the sporangia alternating above and below the node, with this bi-lineal arrangement becoming less distinct as the tetraspores mature. The tetrasporangial initials are immersed when first recognizable; as they enlarge they spread the cortical cells that cover them and become exposed, but they do not project beyond the cortical cells except during the process of liberation.

Ceramium pacificum (Collins) Kylin, 1925:61; — Smith, 1944:326. *pl. 83, fig. 3.*

Present in abundance throughout the range lining the edges of shallow tidepools between HHLW and LHLW levels.

Ceramium washingtoniense Kylin, 1925:62. *fig. 41.*

Known from a collection made in August by F. P. Sipe between Sea Lion Point and Cape Perpetua. The alga grew between the LHLW and MLLW tide levels and in association with *Plocamium pacificum* and *Corallina densa*. The *C. washingtoniense* reported from the Cape Arago region by Sanborn and Doty (*ined.*) is a form of *C. pacificum*.

Ceramium californicum J. Agardh, 1894:45.

Thallus up to 6 cm. high, light red; primary branching alternate with many adventitious branches in the lower portion of the thallus; many of the adventitious branchlets opposite each other or opposite a larger branch; cortical bands in the upper part of the thallus prominent and leaving about one-fourth of the internode uncorticated; this proportion of uncorticated area decreases about 6–9 dichotomies below the tips and near the base of the thallus the major axes are almost or entirely corticated; procarps appearing along the upper abaxial (usually) surfaces; the cystocarp naked except for a short involucral branchlet developing just below it; tetrasporangia protruding from the upper edge of the cortical bands, developing as in *C. Gardneri*.

Epiphytic on *Gracilaria Sjöstedtii* in lower Coos Bay and about Cape Arago in July (*MD 4631*, cystocarpic; *MD 6315*, tetrasporic; *O'Neal 449*; *MD 5026*, ?male).

Ceramium Gardneri Kylin, 1941:29; — Smith, 1944:325. *pl. 84, fig. 2.*

On lightly wave-swept rocks (*MD 4200*, South Bay, cystocarpic in January); and on the wharf at Charleston (*C. L. Doty, 1929*, July). This latter collection looks very much like material collected at the type locality. It seems that, since this species forms low mats of interlaced erect thalli just below and with *Lessoniopsis*, its place in the vertical scale must be in the lower part of the MLLW and LLLW zone.

In addition to its growing in a distinctive habitat this species differs from the next above in that the uncorticated internodes become progressively longer from the apex to the base of the thallus and throughout most of the thallus occupy about four-fifths or less of the axial surface. The main axis is conspicuously dichotomous and bears very few simple lateral branchlets The tetrasporangia protrude at maturity from the lateral and upper surfaces of the nodal cortication. On upper dichotomies they are developed in a ring about the node, with those on the adaxial side developing first; on the lowest dichotomies the tetrasporangia appear first on the adaxial side and may or may not appear later on the other surfaces of the dichotomies.

MICROCLADIA Greville, 1830

Microcladia Coulteri Harvey, 1853:209. *pl. 33, fig. A*; — Smith, 1944:329. *pl. 86, figs. 1–2.*

Known only from two collections in the Brookings area in July (*MD 6108* on *Iridophycus* and *MD 6190* on *Gigartina californica*).

Microcladia borealis Ruprecht, 1851:259; — Smith, 1944:330. *pl. 85, fig. 11.*

Throughout the range in shaded places exposed to the surf and therefore the vertical range is indefinite but where this alga appears with *Lessoniopsis* and *Postelsia* it is above or just in the top of the *Lessoniopsis* zone. At Mussel Point, Pacific Grove, California, it usually grows in the LHLW to MLLW zone.

Farlow (1875:372) gives the only record of *Microcladia californica* growing in Oregon.

PLUMARIA Stackhouse, 1809

Plumaria filicina (Farlow) comb. nov.

Ptilota plumosa var. *filicina* Farlow, 1875:374.

Ptilota filicina (Farlow) J. Agardh, 1876:76; — Smith, 1944:333. *pl. 85, figs. 5–6.*

Throughout the range as an epiphyte. Cystocarpic, antheridial, and tetrasporic during the summer months.

Plumaria tenuis (Kylin) comb. nov.

Ptilota tenuis Kylin, 1925:60. *fig. 40*; — Collins *et al.*, 1903, Phyc. Bor.-Amer. fasc. 23:1148.

Saxicolous; South Bay (*MD 4103*) and Brookings (*MD 4178*) in December, tetrasporic.

This species differs from *P. filicina* in being much more delicate throughout and in having many of the opposite branchlets similarly developed. The most conspicuous difference is that the tetrasporangia are not produced in a head-like cluster of slender branchlets but arise from the serrations along the upper surface of the branchlets.

Plumaria hypnoides (Harvey) comb. nov.
Ptilota hypnoides Harvey, 1833a:164; — Smith, 1944:332. *pl. 85, figs. 3–4.*

Throughout the range, usually on *Calliarthron* spp.

Plumaria californica (Ruprecht *ex* Harvey) comb. nov.
Ptilota californica Ruprecht *ex* Harvey, 1853:222; — Smith, 1944:332. *pl. 85, figs. 1–2.*

From Oregon there are collections from Lighthouse Beach, North Bay and South Bay.

This species differs from *Pl. asplenioides* [1] in having longer, narrower simple branchlets, serrulate only on the abaxial surface, and these not decurrent below. From *Pl. densa* [2] it differs in having almost smooth branchlets that are more slender, though sometimes their crowded appearance gives the impression that one has collected a form of *Pl. densa.*

ANTITHAMNION Nägeli, 1847

Antithamnion defectum Kylin, 1925:46. *fig. 27*; — Smith, 1944:308. *pl. 87, figs. 1–2.*

Only known from the Cape Arago region (*MD 4198*; *MD 4201*) where it is usually epiphytic or on hydroids.

Antithamnion glanduliferum Kylin, 1925:47. *figs. 28e–g*; — Smith, 1944:310. *pl. 77, fig. 4.*

Only collected once (*MD 2234*) on *Fucus evanescens* in the mouth of Haynes Slough, Coos Bay.

This species is very much like *A. pacificum* and differs from that species in that it has gland cells and the tetrasporangia are sessile. From *A. occidentale* it differs both in the complete lack of verticils and in having more delicate, only slightly tapered branchlets, the cells of which are quite rounded in the corners so as to seem rather widely separated. In both of these species the diameter of the terminal cell of a branchlet is usually about half that of the basal cell and the apices are blunt. *Antithamnion glanduliferum*, while it may be relatively short and bushy in habit, tends

[1] **Plumaria asplenioides** (Turner) comb. nov.
Fucus asplenioides Turner, 1808: *pl. 62.*
Ptilota asplenioides (Turner) C. Agardh, 1822:387.
Farlow (1875:375) says that, "this occurs in Oregon, and is a common species of Alaska." If this is correct it is the only record and only mention of this species south of Canada with the exception of one old record (Harvey and Bailey, 1851) from Puget Sound. The material distributed in the Phyc. Bor.-Amer. is similar in size of frond and branch breadth to *Pl. hypnoides*, but the bases of the ultimate branchlets are strongly decurrent toward the base of their parent axis. De Toni (1903:1378) considered *Pt. asplenioides* to be related to *Pt. californica* Ruprecht.

[2] **Plumaria densa** (C. Agardh) comb. nov.
Ptilota densa C. Agardh, 1822:387; — Smith, 1944:333. *pl. 85, figs. 7–8.*

to become long and lax like *A. pacificum*; *A. occidentale* usually develops a stronger bushier thallus than either.

Antithamnion Kylinii Gardner, 1927d:411. *pl. 89, fig. 1*; — Smith, 1944:307. *pl. 77, fig. 1*; *pl. 78, fig. 5.*

Dredged on dead shells in South Slough above Charleston, July (*MD 4718a*). The specimens compare very well with an isotype in the Dudley Herbarium.

Among the Pacific Coast pectinate species, *A. Kylinii* is characterized by having a branchlet opposite each major branch, and further distinguished by having only a few patent gradually-tapered acutely-tipped branchlets on a major branchlet. These outwardly directed but widely spreading ultimate branchlets are like the tip of the parent branchlet and arise from its outer part. The basal 3 to 6 cells of the parent branchlet bear as a rule only dwarfed branchlets, if any.

Antithamnion occidentale Kylin, 1925:47. *fig. 30a–d*; — Smith, 1944:312.

A common alga on the wharf timbers at Charleston and in the Siuslaw Bay with cystocarps in July.

Carpospores irregularly rounded polygonal and up to 48 μ in their longest dimension. Tetrasporangia up to 47 x 65 μ. See *A. glanduliferum* for a comparison with that species.

Antithamnion pacificum (Harvey) Kylin, 1925:47. *fig. 28c–d, fig. 29*; — Smith, 1944:310.

On large kelps known definitely only from the Cape Arago region.

Antithamnion pygmaeum Gardner, 1927d:413. *pl. 91–93*; — Smith, 1944:309. *pl. 78, fig. 4*; *pl. 80, fig. 1.*

Washed in on *Plumaria hypnoides* at Lighthouse Beach (*MD 5029*), and scraped from the surface of crustaceous corallines (*MD 5278*) at Middle Bay. Both collections made in July.

Antithamnion subulatum (Harvey) J. Agardh, 1892:20; — Kylin, 1925:50. *fig. 31*; — Smith, 1944:312. *pl. 78, fig. 3.*

Male thalli (*MD 4217*) Sunset Bay, June; dredged on shells in South Slough above Charleston (*MD 4718b*), tetrasporic, July.

Branchlets mostly in pairs except at origins of major branches where there is usually a verticil of three. Branchlets mostly not over 20 μ at their bases. Tetrasporangia broadly elliptical, up to 52 x 82 μ.

Antithamnion tenuissimum Gardner, 1927c:377. *pl. 77.*

The branching, cells, and general proportions are quite like Gardner's description and figure; however no gland cells were found and the largest tetrasporangia were about 50 x 70 μ (*MD 2359* and *J. C. Queen 106*, floating timber at Marshfield on Coos Bay, July). The tetrasporangia are elliptical at first; pyriform and finally almost spherical at maturity.

Antithamnion uncinatum Gardner, 1927d:408. *pl. 89, fig. 2*; *pl. 90*; — Smith, 1944: 312. *pl. 76, fig. 4.*

Throughout the range as an epiphyte chiefly on *Nereocystis*. Male and

tetrasporic individuals were collected from this host in July south of the Chetco River (*MD 6089*); material with abundantly developed tetrasporangial fascicles in June at Cape Blanco (*O'Neal 423*); young female material washed in near the south jetty of Coos Bay (*MD 2499*, collected by *Mrs. Mildred Detling*) in July; among many others.

Antithamnion Baylesiae Gardner, 1927c:375. *pl. 75, fig. 1*; — Smith, 1944:313.

Dredged on shells in the channel of South Slough above Charleston (*MD 4721*, July).

PLATYTHAMNION J. Agardh, 1892

Platythamnion heteromorphum J. G. Agardh, 1892:23; — Smith, 1944:315. *pl. 79, fig. 3.*

Sunset Bay (*MD 2677*) tetrasporic in July.

Platythamnion villosum Kylin, 1925:51. *figs. 32a–b, 33a–d*; — Smith, 1944:315. *pl. 79, fig. 2.*

Tetrasporic (*MD 6308*) at Middle Bay in July and antheridial and cystocarpic (*MD 4217*) at Sunset Bay in June.

Platythamnion pectinatum Kylin, 1925:53. *figs. 32d, 33e, 34a–c*; — Smith, 1944: 316. *pl. 79, fig. 1.*

Throughout the range mostly on floating timbers. Tetrasporic and cystocarpic thalli found throughout the summer.

CALLITHAMNION Lyngbye, 1819

Callithamnion Pikeanum Harvey, 1853:230; — Smith, 1944:318. *pl. 18, fig. 2.*

Throughout the range on vertical surfaces between HHLW and LHLW levels. Tetrasporic material collected at Cape Blanco in early summer (*C. L. Doty 2514*). Male thalli were collected (*MD 6340*) on *Odonthalia floccosa* at South Bay in January. The spermatia are produced at the apices of sets of bushy branches originating singly or in pairs from the upper ends of cells on the upper branches of the thallus.

Callithamnion Pikeanum var. **pacificum** (Harvey) Setchell & Gardner, *in* Gardner, 1927d:406. *pl. 87, figs. 2–3.*

Tetrasporic material collected in late June at Cape Blanco (*O'Neal 422b*). Throughout the range at the same levels as the species.

Callithamnion Pikeanum var. **laxum** (Setchell & Gardner) comb. nov.

Ceratothamnion Pikeanum var. *laxum* Setchell & Gardner, 1903:339. Originally forma *laxum*.

Callithamnion laxum (Setchell & Gardner) Setchell & Gardner, *in* Gardner, 1927d: 407. *pl. 88.*

This variety has been collected at Otter Point (*MD 6223*) in early July, and in addition tetrasporangial, antheridial, and cystocarpic material at Brookings in late June (*O'Neal 284b*). Previously reported only from the Puget Sound region.

Various stages in the development show that the procarp forms from the

basal cell of a 6- or 7-celled apical branch, with two primary cystocarps developing first in a bilateral position with regard to the parent branch.

GRIFFITHSIA C. Agardh, 1817

Griffithsia pacifica Kylin, 1925:58. *figs. 39–40*; — Smith, 1944:324. *pl. 83, fig. 2.*

In tufts below MLLW at Sunset Bay (*O'Neal 429*, June) and at North Bay (*MD 4979*, July).

DELESSERIACEAE

DELESSERIA Lamouroux, 1813

Delesseria decipiens J. Agardh, 1872:58; — Smith, 1944:338. *pl. 87, figs. 3–4.*

Throughout the range between the MLLW to LLLW levels on more or less shaded rocks. Tetrasporic and cystocarpic in the summer months.

MEMBRANOPTERA Stackhouse, 1809

Membranoptera platyphylla (Setchell & Gardner) Kylin, 1924:15. *figs. 7–8.*

Fronds up to 1.5 cm. broad and up to 8 cm. tall, with much divided tips; midrib conspicuous below and sometimes over 1 mm. broad; lateral veinlets inconspicuous and rebranched abaxially; margin minutely serrulate, but sometimes sinuate to nearly smooth; cystocarps toward the apex of the ultimate branchlets, often solitary, but at times in a linear series of 2 or 3, hemispherical, the ostioles projecting forward, ostioles usually cylindrical but at times funnel-like; tetraspores in rows lateral to the midrib, in the lower parts of the blade extending out along the lateral veinlets.

On piling of the old wharf in lower Coos Bay (*MD 4616*, tetrasporic in July). The Oregon material is quite similar to specimens in the University of California herbarium identified as *M. platyphylla* by Gardner.

Membranoptera multiramosa Gardner, 1926:209. *pl. 19, fig. 1*; — Smith, 1944:337. *pl. 86, figs. 3–4.*

Pendant from rocks in shaded situations between MLLW and LLLW at South Bay (*MD 1994*) in July and at Middle Bay (*MD 4204*) in January. Both collections are tetrasporic.

Membranoptera dimorpha Gardner, 1926:211.

Throughout the range south to the Rogue River Reef (*MD 6171*) and to Brookings (*MD 2601* and *MD 6111*). Growing below the MLLW level.

ERYTHROGLOSSUM J. Agardh, 1898

Erythroglossum californicum J. Agardh, 1898:176; — Kylin, 1941:31. *pl. 10, fig. 28*; — Smith, 1944:339. *pl. 87, figs. 5–6.*

Two collections known from Oregon, one washed ashore near the south jetty of Coos Bay (*MD 2496*) and the other growing near LLLW on a vertical rock surface a foot below the bottom of a large tidepool at Middle Bay (*MD 5287*).

POLYNEURA Kylin, 1924

Polyneura latissima (Harvey) Kylin, 1924:37. *figs. 27–28*; — Smith, 1944:341. *pl. 87, fig. 8.*

Throughout the range below the MLLW level, both cystocarpic and tetrasporic thalli collected during the summer.

PHYCODRYS Kützing, 1843

Phycodrys Setchellii Skottsberg, 1922:433. *fig. 4*; — Smith, 1944:342. *pl. 87, fig. 2*; *pl. 88, fig. 7.*

One collection (*MD 4205*) in January near the LLLW level on rocks over a deep pool at Middle Bay, cystocarpic.

The Oregon thalli are narrower than those usually found along the coast of California. The venation and thickness of the blade is as in specimens seen from California.

NIENBURGIA Kylin, 1935

Nienburgia Andersoniana (J. Agardh) Kylin, 1935:1; — Smith, 1944:345. *pl. 90, figs. 1–2.*

The only specimens of *Nienburgia* collected in Oregon are juvenile (*MD 4634*, Middle Bay, and *MD 1856*, Sunset Bay); so that they cannot be identified with absolute certainty.

The material at hand is narrow and like *N. Andersoniana* rather than like *N. borealis* which seems to be a broader alga. *N. borealis* is recorded only from the Puget Sound region.

NITOPHYLLUM Greville, 1830

In Sanborn and Doty (*ined.*) *Nitophyllum mirabile* Kylin is credited to Oregon on the basis of a specimen collected by Hazel R. Hayden at Lighthouse Beach and identified by Setchell. After examining this specimen in the herbarium of the University of California (number *552381*) the author is of the opinion that it is *Hymenena Smithii* Kylin.

HYMENENA Greville, 1830

Hymenena multiloba (J. Agardh) Kylin, 1935:3; — Smith, 1944:350. *pl. 89, fig. 2.*
Nitophyllum multilobum J. Agardh, 1876:698.
Nitophyllum Fryeanum Harvey, 1858:128.
Hymenena Fryeanum (Harvey) Gardner, 1927a:244.

Washed ashore in July south of the mouth of the Chetco River (*MD 6101*, July) and collected in January between the LHLW and MLLW levels on rocks at South Bay (*MD 4104*). Both collections were tetrasporic. See under *H. Setchellii* Gardner for a discussion of the nomenclature.

Hymenena flabelligera (J. Agardh) Kylin, 1924:83. *fig. 68*; — Smith, 1944:348. *pl. 89, fig. 3.*

Throughout the range in somewhat exposed situations; between the MLLW and LLLW levels.

Hymenena Smithii Kylin, 1941:33. *pl. 11, fig. 31*; — Smith, 1944:351. *pl. 89, fig. 1.*

Tetrasporic material was found cast ashore at Sunset Bay in July (*MD 2411*). In the University of California herbarium (number *552381*) is a fragment of a cystocarpic thallus found floating at Lighthouse Beach in July by *Hazel R. Hayden* (*42*).

Hymenena Setchellii Gardner, 1927a:245. *pl. 28–31*; — Smith, 1944:350. *pl. 89, fig. 4.*
Nitophyllum Fryeanum Farlow, 1878, *in* Alg. Exc. Amer. Bor. no. 69; — Collins *et al.*, 1911, Phyc. Bor.-Amer. fasc. 35:1742; — Nott, 1900:22.
Hymenena Fryeana (Nott) Kylin, 1924:81; — Kylin, 1941:33.
non H. Fryeana Gardner, 1927a:244.

Frequent on sunken stumps in Sunset Bay at LLLW and lower levels. Occasionally washed ashore at other stations on Cape Arago. Cystocarpic, tetrasporic, and antheridial during late July and August.

In 1858 Harvey described *Nitophyllum Fryeanum* on the basis of poor material from San Francisco. Nott (1900:23) pointed out that this *N. Fryeanum* of Harvey's was probably the same as *N. multilobum* of J. Agardh, 1876. Kylin (1924:58) transferred this entity to *Myriogramme*, selecting the specific name of *multilobum* of J. Agardh rather than the earlier specific name *Fryeanum* of Harvey. In 1925, after better material had come into his hands, he verified the mutual synonymy of these last two specific names. Gardner (1927:244) found later that the *M. multiloba* (J. Agardh) Kylin belonged to the genus *Hymenena* as delimited by Kylin in 1924, and so he transferred this to *Hymenena* and called it *H. Fryeanum* (Harvey) Gardner. He was not justified in doing this for Kylin (1924:81) had already used the name *H. Fryeanum* when he made the combination *H. Fryeanum* (Farlow *in* Nott) Kylin. Therefore *H. Fryeana* (Harvey) Gardner must be discarded as a homonym and the next validly published name for this entity, *Hymenena multiloba* (J. Agardh) Kylin (1935:3), must be used.

In 1878 Farlow distributed, in the Alg. Exsic. Amer. Bor. No. 69, an alga he erroneously determined as *Nitophyllum Fryeanum* Harvey. Nott (1900:22) published a description of this as interpreted by Farlow but this name must be rejected as a homonym of *N. Fryeanum* Harvey as discussed above. Though Kylin (1924:81) made the combination *H. Fryeana* (Farlow) Kylin on the basis of Nott's (1900:22) description of the species and considered it valid because it was used in a different genus, this combination must be rejected because once the name for an entity is discarded as a homonym it cannot be used again; not only not within the same genus for another species, but neither can it be used for the same entity in any other genus. Since the name *Hymenena Fryeanum* is invalid, the next legitimate epithet for this entity, *H. Setchellii* Gardner (1927a:245), must be used.

There is no physical similarity between *H. Setchellii* Gardner and *H. multiloba* (J. Agardh) Kylin.

Hymenena Kylinii Gardner, 1927a:242. *pl. 32*; — Smith, 1944:349.

Throughout the range south of Cape Blanco (*MD 2530b*, cystocarpic in July) to Brookings (*MD 4175*, tetrasporic in December).

The above material compares well with Gardner's type in the University of California herbarium but in general has broader more divided apices.

Hymenena cuneifolia sp. nov.

PLATE 14, FIG. C

Laminae fertiles erectae e thallo prostrato in superficie inferiore per proliferationes rhizoideas affixo, usque ad 10 cm. altitudine, segmentis plerumque 1.5 cm. latitudine; costa ad basim ipsam partis indivisae frondis restricta, supra venulis subparallelis ad locum basium loborum ultimorum egressis; frons plana, supra expansa, marginibus autem ramorum rectis ut systemata ramificationis flabellata apellari non possint; tetrasporangia secundum venulas nata, in partibus frondium centralibus inferioribusque primum visa.

Fertile blades erect from a prostrate thallus anchored on the underside by rhizoidal proliferations, up to 10 cm. high with the segments mostly 1.5 cm. broad; midrib restricted to the very base of the undivided portion of the frond; above this more or less parallel veinlets extending to the bases of the ultimate lobes; frond plane, expanded above but branch margins straight so that the branch systems cannot be said to be flabellate; tetrasporangia borne along the veinlets, appearing in the central and lower portions of the fronds first.

TYPE: *MD 2134* (Dudley Herbarium *306920*), on the stones of the old jetty in Coos Bay at the mouth of South Slough, June 17, 1939. **COTYPE:** *C. L. Doty 1952* (Dudley Herbarium *306919*), washed in at Sunset Bay, June 11, 1940.

In addition to the type there is an apparently sterile specimen (*Charlotte L. Doty 1952*) that was washed in at Sunset Bay in early July.

This species differs from *H. flabelligera* in having a much broader, thinner thallus; in having an inconspicuous midrib visible for only a short distance (less than 2 cm.) above the base; and in having the branches of all orders more or less cuneiform with broadly rounded digitately divided apices. The tetrasporic material is distinctive in that the tetraspores mature early on the disc or in the central or basal parts of the blade. The blades are usually broadly rounded just above the short (2–4 mm.) stipe.

CRYPTOPLEURA Kützing, 1843

Cryptopleura brevis Gardner, 1927a:241. *pl. 25, fig. 2*; *pl. 26.*

Vertical range not well known but presumed to be HHLW to LLLW. The Oregon collections at hand are: *MD 4182*, Sunset Bay; *MD 6199*, Harris State Park; and *MD 6335*, washed onto the beach south of the Chetco River.

This species is only about half the size of *C. lobulifera* and grows in low stands somewhat like *Hymenena multiloba*. The branching is like that of *C. lobulifera* but the tetrasporangial sori tend to be produced on more or less lateral and terminal lobes instead of on merely enlarged ruffles as in that species.

Cryptopleura Ruprechtiana (J. Agardh) Kylin, 1924:93.

The exact identity of this entity can be questioned and the correct name for it may be *Hymenena* (*Cryptopleura*) *fimbriata* Postels & Ruprecht

(1840). However under the name *C. Ruprechtiana* there have been segregated the following specimens from Oregon: *MD 6103a*, washed onto the beach south of the Chetco River; *O'Neal 380*, Brookings; *O'Neal 385*, Brookings; *MD 6342* (collected by Miss Marjorie Maxwell), Mussel Reef, Cape Arago; *MD 1730*, Devil's Punch Bowl, Lincoln County.

Cryptopleura violacea (J. Agardh) Kylin, 1924:89; — Smith, 1944:352. *pl. 90, fig. 3.*

Rare in the southern part of the range.

The specimens referred to this species have the tetrasporangia in linear sori, and the cystocarps for the most part scattered along the margins of the thalli. The collections referred to *C. crispa* have the tetrasporangia and cystocarps chiefly in lateral proliferations of the margin. In addition, the branching of *C. violacea* is not at all flabellate and the upper parts of branches tend to be linear and narrower. In *C. crispa*, which likewise is not flabellate, the blades are more cuneate and not as linear as in *C. violacea*. Proliferous outgrowths are more frequent in *C. crispa* than in *C. violacea*.

Cryptopleura crispa Kylin, 1924:90.

Rare growing between MLLW and LLLW tide levels (*MD 2374*, Cape Arago, collected by John Queen; and *O'Neal 381*, ?Brookings).

BOTRYOGLOSSUM Kützing, 1843

Botryoglossum Farlowianum (J. Agardh) De Toni, 1900:676; — Smith, 1944:354. *pl. 91, figs. 1–2.*

Common throughout the range on rocks below the LLLW level and usually on *Cystoseira osmundacea*. One collection (*H. C. Luce 6a*, collected by Clarence Hubbard) was obtained from an otter trawl brought up 35 fathoms off a mud and sand bottom, 8 miles north of the Coos Bay bar.

RHODOMELACEAE

RHODOMELA C. Agardh, 1822

Rhodomela larix (Turner) C. Agardh, 1822:376; — Smith, 1944:374. *pl. 97, fig. 1.*

Throughout the range and one of the conspicuous indicators of the LHLW to MLLW zone.

ODONTHALIA Lyngbye, 1819

Odonthalia oregona sp. nov.

PLATE 13, FIG. B

Thallus usque ad 17 cm. altitudine; rami ubique teretes, alternati distichique, gradatim attenuati, minus quam 1 mm. diametro, supra circa 0.25 mm. diametro; niger cum exsiccatus et foliis herbari affixus; cystocarpi minus quam 0.5 mm. diametro, in racemis crebris, non autem confertis; tetrasporae in ramulis terminalibus dense factis, non autem valde ramosis natae.

Thallus up to 17 cm. tall; branches terete throughout, less than 1 mm. in diameter and the upper branches about 0.25 mm. in diameter; black in color when dried and mounted on a herbarium sheet; the branching alter-

nate and distichous; the branches gradually attenuated; cystocarps less than 0.5 mm. in diameter, in close but not dense racemes; tetraspores borne in densely produced but not strongly clustered terminal branchlets.

TYPE: *MD 6142d* (Dudley Herbarium *306917*), cast ashore about 1 mile south of the mouth of the Chetco River, Curry County, Oregon, July 3, 1944.

The slender, less densely tufted terete branches, and the minute cystocarps readily distinguish this species from others along this coast. The cystocarps of *O. floccosa* are over 0.5 mm. in diameter at maturity, and are usually about two or three times the diameter of those of *O. oregona*.

Odonthalia washingtoniensis Kylin, 1925:76.
Odonthalia semicostata Setchell & Gardner, 1903:336. *pl. 26–27*; — Collins *et al.*, 1902, Phyc. Bor.-Amer. fasc. 19:941.

Common on rocks between the MLLW and LLLW levels as far south as Cape Arago, and then rare as far south as Brookings (*O'Neal 402*, June).

Odonthalia floccosa (Esper) Falkenberg, 1901:607; — Smith, 1944:375. *pl. 97, fig. 2.*
Odonthalia aleutica Setchell & Gardner, 1903:333 (*non Rhodomela aleutica* C. Agardh); — Collins *et al.*, 1903, Phyc. Bor.-Amer. fasc. 23:1147.

Throughout the range and locally dominant between LHLW and MLLW.

Most of the Oregon collections can be referred to the variety *macrantha* (forma *macrantha* of Setchell & Gardner), though the variety *comosa* (forma *comosa* of Setchell & Gardner) is likewise to be found.

The statement that the cystocarps are borne in dense "head-like" glomerules is not correct for all forms. The very dense antheridial heads surrounded by rather long bract-like branchlets are illustrated by Setchell & Gardner (1903: pl. 27, fig. 50). The antheridial branches appear as colorless or brownish asymmetrical clubs in head-like clusters of short corymbose branchlets terminating the upper lateral branches. These are surrounded by the short vegetative bract-like branchlets mentioned above. Tetrasporic thalli are usually tufted in the same manner, but this is not true of the cystocarpic thalli collected along the Oregon coast. In many thalli the cystocarps are borne in racemose clusters along the upper branchlets and there are no short branchlets particularly associated with them.

POLYSIPHONIA Greville, 1824

Polysiphonia Collinsii Hollenberg, 1944:481. *figs. 2–5, 8*; — Smith, 1944:363.

Throughout the range, usually growing in low circular patches on vertical surf-swept rocks, mussels (*Mytilus* sp.), and coralline algae, between HHLW and LHLW levels. Cystocarpic and tetrasporic in December (*MD 5392*). No attempt was made to separate the varieties.

Polysiphonia paniculata Montagne, 1842:254; — Hollenberg, 1944:480. *fig. 7.*
Polysiphonia californica Smith, 1944:362. *pl. 93, fig. 1.*

Throughout the range between MLLW and LLLW and growing inter-

mingled with *Schizymenia pacifica* and *Porphyra occidentalis*. A collection from mussels, collected (*MD 5392c*) in December at Lighthouse Beach, has been identified by Hollenberg as a form of this species. As might be expected this material was young and sterile.

Polysiphonia Hendryi Gardner, 1927e:101. *pl. 24–25*; — Smith, 1944:363. *pl. 93, figs. 3–4*; — Hollenberg, 1944:482.

One collection from the flattened surface of the central axis of *Egregia* (*O'Neal 337* and *MD 2480*) at Sunset Bay, in July, has been determined as this species by Hollenberg.

Polysiphonia pacifica Hollenberg, 1942b:777. *figs. 2, 3, 12, 13*; — Smith, 1944:359. *pl. 94, fig. 3.*

Throughout the range but present in greatest abundance at Cape Arago between the LLHW and LHLW levels, on shaded vertical rocks.

Polysiphonia Snyderae Kylin, 1941:35. *pl. 12, fig. 34*; — Hollenberg, 1942b:781; — Collins *et al.*, 1899, Phyc. Bor.-Amer. fasc. 13:638.

One collection of freely and finely branched specimens was found floating in South Slough (*MD 2468*) in July. This material has the characteristic arrangement of scar cells and tetraspores but lacked the delicate and irregularly branched percurrent axis so conspicuous in the *Phycotheca* specimen and in Kylin's figure.

PTEROSIPHONIA Falkenberg, 1897

Pterosiphonia dendroidea (Mont.) Falkenberg, 1901:268; — Smith, 1944:366. *pl. 95, fig. 3.*

Throughout the range below the MLLW level. Generally growing on rocks but occasionally epiphytic. Isolated thalli have been found on the tops of flat rocks above the LLHW level where the rocks are continually dampened by spray.

Pterosiphonia bipinnata (Postels & Ruprecht) Falkenberg, 1901:273.

Throughout the range in tufts on vertical rocks below LHLW.

Pterosiphonia bipinnata var. **robusta** (Gardner) comb. nov.
Pterosiphonia robusta Gardner, 1927e:102.

P. robusta Gardner is not sufficiently distinct from *P. bipinnata* to merit recognition as a species, but it does differ sufficiently to be considered a variety. The major difference is in the strongly recurved simple branchlets that hold the major axes in symplocoid tufts. It also differs in that there are usually 14–15 pericentral cells. Tufts of this variety are taller and more apt to become very dark or blackish when dried on the herbarium sheet.

Cystocarpic, antheridial, and tetrasporic material was present in the collection (*MD 6130*) made along the north shore of Chetco Cove in July.

Pterosiphonia gracilis Kylin, 1925:72, *fig. 47a.*

One collection (*MD 2678*) from Sunset Bay in July. The thalli were tetrasporic.

PTEROCHONDRIA Hollenberg, 1942

Pterochondria Woodii (Harvey) Hollenberg, 1942a:533; — Smith, 1944:368. *pl. 95, figs. 1–2.*

Throughout the range on the usual host, *Cystoseira osmundacea*, but occasionally on other large brown algae.

HERPOSIPHONIA Nägeli, 1846

KEY TO THE NORTHEAST PACIFIC SPECIES OF *HERPOSIPHONIA*

1. Simple ultimate branchlets with 8 pericentral cells 2
1. Simple ultimate branchlets with 12 pericentral cells ..... **H. verticillata**
   2. Main axes with 8 pericentral cells; segments in main axes over 1.5 times as long as broad ..... **H. grandis**
   2. Main axes with 10–12 pericentral cells; segments less than 1.5 times as long as broad 3
3. Thalli erect, saxicolous; length of most of the compound branchlets increasing with age, giving the thallus a triangular outline ..... **H. rigida**
3. Thalli prostrate, on coralline algae; length of many of the upper compound branchlets remaining equal to or shorter than the simple branchlets, giving the thallus a linear outline ..... **H. parva**

Herposiphonia rigida Gardner, 1927e:100. *pl. 23*; — Smith, 1944:369. *pl. 95, fig. 5*; *pl. 96, fig. 3.*

Throughout the range between MLLW and LLLW levels. Tetrasporic in July.

Herposiphonia parva Hollenberg, 1943:575. *figs. 8–9.*
Herposiphonia pygmaea Smith, 1944:369. *pl. 96, fig. 2.*

On *Bossea* (*MD 4199*) at LHLW levels, Sunset Bay, in December.

AMPLISIPHONIA Hollenberg, 1939

Amplisiphonia pacifica Hollenberg, 1939:380. *figs. 1–13*; — Smith, 1944:372. *pl. 96, figs. 7–9.*

Known in Oregon only from sterile and tetrasporic specimens (*e.g.*, *MD 4110*) collected from several Cape Arago stations in December and January. It grows on rocks and algal holdfasts between MLLW and LLLW and probably also at lower levels.

LAURENCIA Lamouroux, 1813

Laurencia spectabilis Postels & Ruprecht, 1840:16; — Smith, 1944:377. *pl. 97, figs. 4–5.*

Throughout the range below the HHLW level, but thalli above the MLLW level dwarfed.

JANCZEWSKIA Solms-Laubach, 1877

Janczewskia Gardneri Setchell & Guernsey, *in* Setchell, 1914a:12; — Smith, 1944: 381. *pl. 98, fig. 1.*

Parasitic on *Laurencia spectabilis* found at South Bay (*MD 4101*, De-

cember) and cast ashore on the same host south of Chetco Cove (*MD 6142b*, July).

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EXPLANATION OF PLATE 11

The name and number in parentheses after the specific name identifies the material from which the photographs were made. The magnification is indicated at the end of each figure description.

Fig. A. *Callophyllis oregona* (*MD 2594*, **type** *Dudley Herb. 306925*). × 0.46.
Fig. B. *Gloiopeltis furcata* (*MD 6133*). × 0.56.
Fig. C. *Iridophycus oregonum* (*MD 4056*, **type** *Dudley Herb. 306918*). × 0.28.

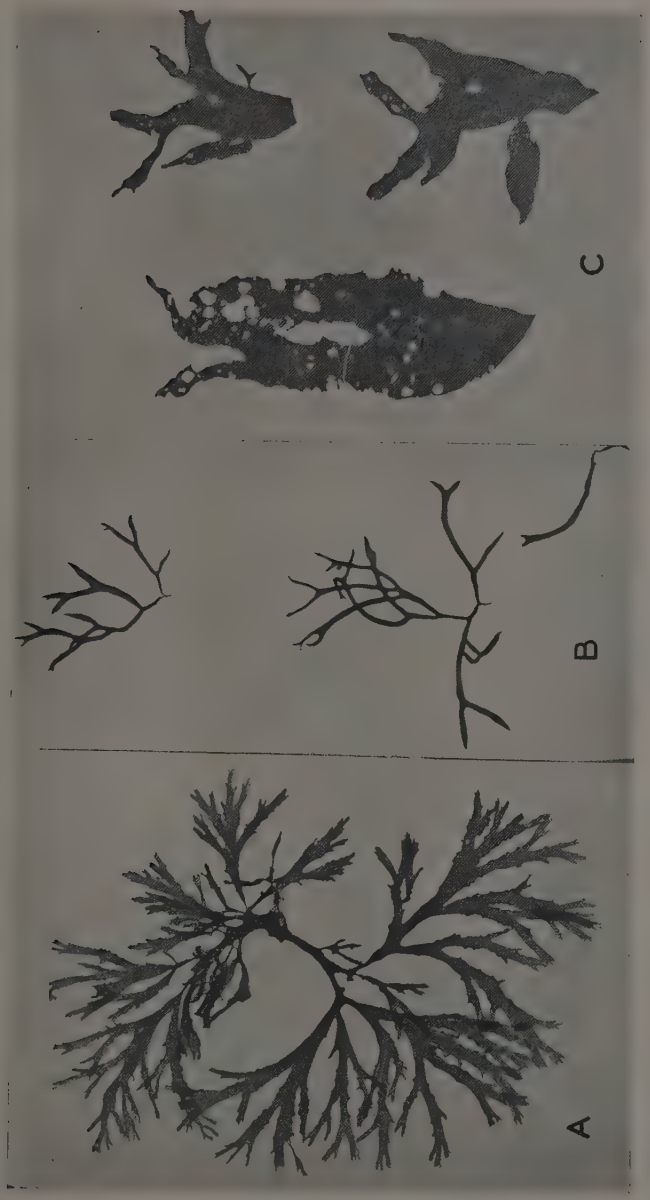

PLATE 11

EXPLANATION OF PLATE 12

The name and number in parentheses after the specific name identifies the material from which the photographs were made. The magnification is indicated at the end of each figure description.

Fig. A. *Fryeella Gardneri* (*MD 5018*). Both tetrasporic and cystocarpic fronds. × 0.5.

Fig. B. *Zanardinula Kylinii* (*C. L. Doty 2440*, **isotype**). × 0.61

PLATE 12

EXPLANATION OF PLATE 13

The name and number in parentheses after the specific name identifies the material from which the photographs were made. The magnification is indicated at the end of each figure description.

Fig. A. *Zanardinula filiformis* (*MD 2295*). × 0.24.
Fig. B. *Odonthalia oregona* (*MD 6142d*, **type** *Dudley Herb. 306917*). × 0.83.

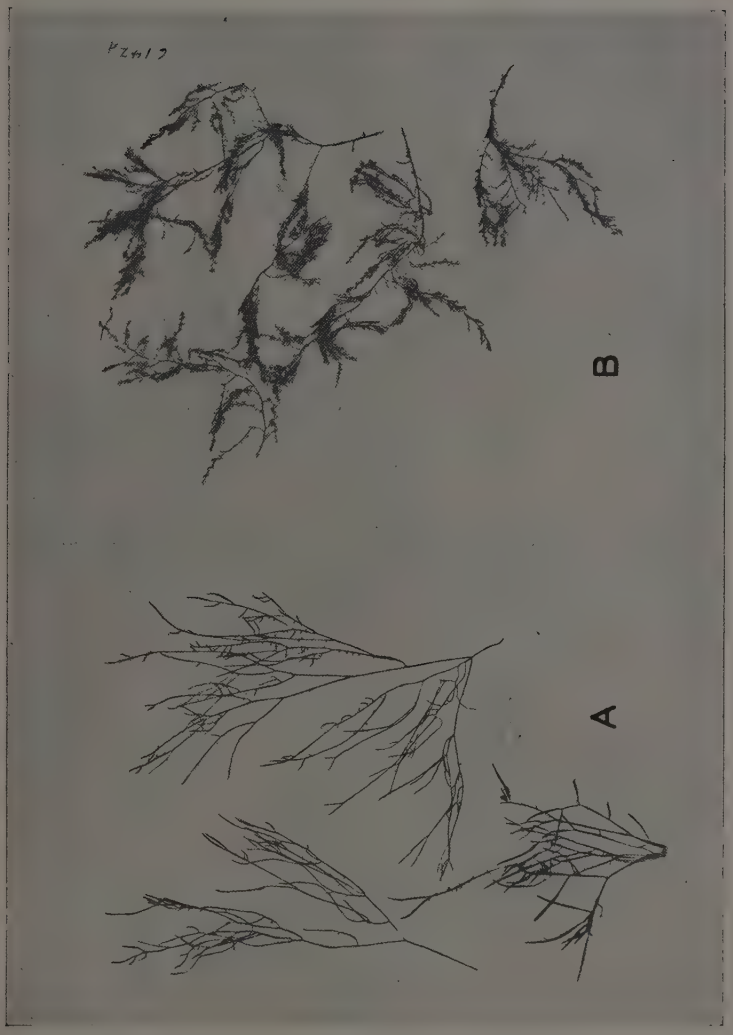

PLATE 13

EXPLANATION OF PLATE 14

The name and number in parentheses after the specific name identifies the material from which the photographs were made. The magnification is indicated at the end of each figure description.

Fig. A. *Erythrophyllum splendens* (*C. L. Doty 1951*, **type** *Dudley Herb. 306922*). × 0.27.
Fig. B. *Plocamium oregonum* (*MD 6151*, **type** *Dudley Herb. 306916*). × 0.5.
Fig. C. *Hymenena cuneifolia* (*MD 2134*, **type** *Dudley Herb. 306920*). × 0.54.

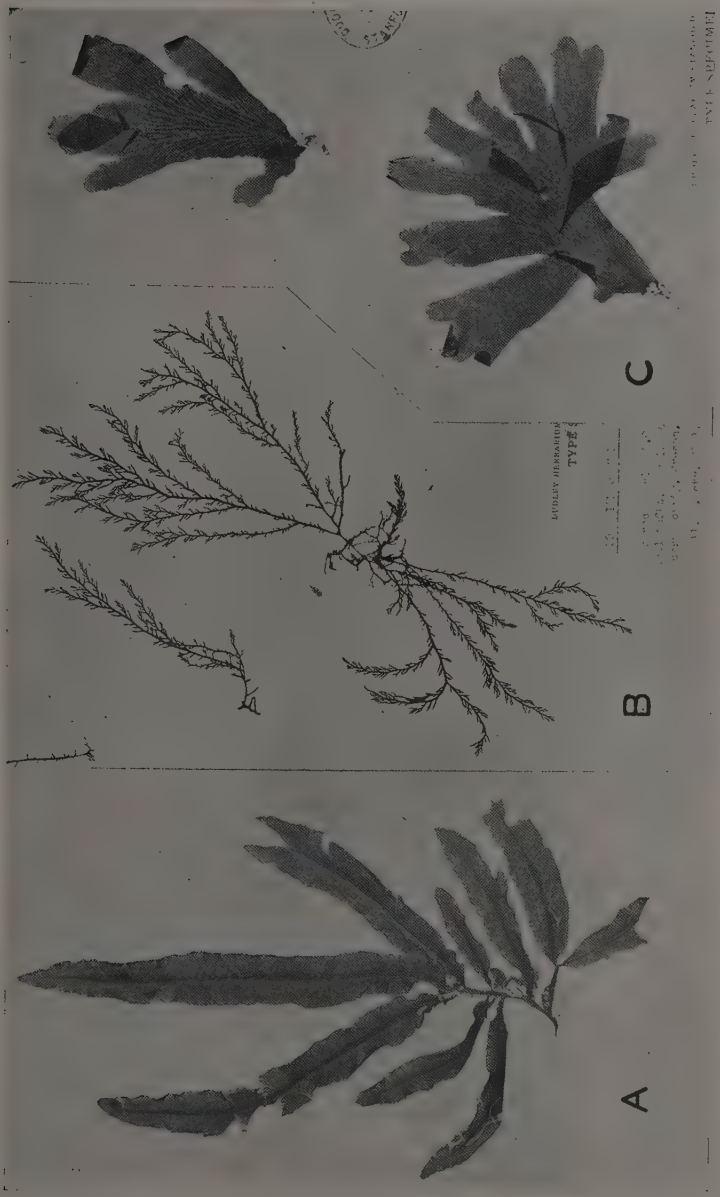

PLATE 14

3(2):217–223 FARLOWIA JULY, 1947

THE HISTORICAL SIGNIFICANCE OF NAMES APPLIED TO REPRODUCTIVE STRUCTURES OF ALGAE

GILBERT M. SMITH

There are various angles from which one may approach the names given reproductive structures of plants. The approach may be etymological and primarily concerned with the derivation of names from classical Greek and Latin. It may be historical and primarily concerned with the dates on which names were proposed. Again, it may be that of the reformer who proposes a substitution of more accurate names for misleading or inaccurate names in current use.

Still another approach, that used in this paper, is the manner in which names, often misnomers, recapitulate development of knowledge concerning the nature of reproductive structures. Discussion of names from this standpoint will be restricted to the algae, both because it is the primary field of interest of the writer, and because many generally used terms were coined to describe reproductive structures of algae.

Study of algae began with Linnaeus' (1743) creation of the order Algae in his Class 24, Cryptogamia. As delimited by Linnaeus this order included both thallose liverworts and true algae; of the latter he recognized four genera — *Chara*, *Fucus*, *Ulva*, and *Conferva*. For more than fifty years botanists describing new species referred them to one of the four Linnaean genera. The climax of this procedure was achieved by Dawson Turner (1809–1818) when he wrote a four volume treatise on the species of *Fucus*. Shortly before 1800 botanists began to recognize other genera than the sacred four of Linnaeus. The first attempts to group these genera into families and orders were solely on the basis of such vegetative characters as form, size, and structure of the thallus. Thus, filamentous genera (called articulate algae) were grouped together irrespective of whether they were green, blue-green, red, or brown algae. The present-day segregation of green, red, and brown algae into separate groups was first proposed by Harvey (1836) when he created what he called the Chlorospermeae, Rhodospermeae, and Melanospermeae. One by one phycologists began to follow the lead of Harvey and by the middle of the nineteenth century his system was in almost universal use.

Linnaeus describes reproductive structures of algae in terms of floral morphology. For *Chara* he describes the appearance of the calyx, stamen, pistil, and seed. He is uncertain about the reproduction of *Fucus* and writes "male flowers?" and "female flowers?" For nearly a century botanists followed Linnaeus' practice of using terms borrowed from floral morphology. This is done in the first comprehensive treatise on algae, that of C. A. Agardh (1823). This use of a terminology borrowed from floral morphology was due to a failure to interpret correctly, rather than to a failure to observe correctly. For example, the drawings of Vaucher (1803)

showing the conjugation of what is now called *Spirogyra* compare favorably with those made by freshmen in college today, yet he speaks of the seeds formed by the conjugation of two tubes with a large number of transverse partitions. In *Ectosperma*, now known as *Vaucheria*, he refers to the reproductive organs as anther and seeds.

Early in the nineteenth century botanists began to abandon the use of floral terms in connection with the algae but we still have a carry-over from that archaic terminology in the present-day retention by phycologists of the terms pericarp, involucre, fructification, and fruiting specimens. Abandonment of floral terminology was initiated by J. G. Agardh (1836) when he began calling reproductive bodies spores instead of seeds. However, it should be noted that in borrowing a term first used in connection with mosses (Hedwig, 1787) he applied it indiscriminately to both sexual and asexual structures. Agardh distinguished between motile and non-motile spores but did not give them special names. The term *zoospore*, now so widely used, was coined by Decaisne in 1842. Decaisne applied the name to both sexual and asexual swarmers; later Pringsheim (1855) restricted its use to asexual reproductive bodies. The current terminology for the various types of non-motile spores of algae is in part borrowed from mycology and in part original with phycologists.

When botanists began to write about spores of algae they did not distinguish between spore and sporangium, the latter also a term introduced by Hedwig (1787) to describe a structure found in mosses. Thuret (1850) was the first to differentiate between spore and sporangia of algae. He also noted that brown algae have two distinctive types of sporangium which he named *trichosporangium* and *oosporangium*. Later (1855) he substituted the names *plurilocular sporangium* and *unilocular sporangium* now so widely used in connection with brown algae.

Most of the terminology for structures associated with sexual reproduction of algae dates from the decade 1850–1860. The term *antheridium* was introduced considerably earlier than this by C. A. Agardh (1823) to describe a distinctive type of reproductive organ he observed in *Polysiphonia*. Agardh called this organ an antheridium because of its superficial resemblance to an anther. Within a few years the same name was also used for a reproductive organ found in brown algae. When Derbès and Solier (1850) observed that antheridia liberated motile reproductive bodies, they called them *antherozoids* and considered them zoospores coming from a special type of sporangium, the antheridium. Thuret's classical studies on fertilization in *Fucus*, the illustrations of which are still republished in texts of today, appeared in 1854. He interpreted what he saw as a swarming of antherozoids about a spore, the *octospore*, liberated from a sporangium of *Fucus*. Fusion of antherozoid with the octospore activated the octospore to develop into a new plant. The next year (1855) Pringsheim described fertilization in *Vaucheria* but thought that it resulted in a spore fruit (Sporenfrucht). In 1858 Pringsheim distinguished between male and female organs of *Oedogonium* and proposed the name *oogonium* for the

latter. He decided against calling the contents of the oogonium an egg because he considered it different from the egg of an angiosperm. Pringsheim called the contents of an oogonium the fertilization sphere or *gonosphere*. He said that a single seed body united with a gonosphere to form the fertilized cell or seed cell, and called this the *oospore*. In the same year that Pringsheim introduced the term oospore, DeBary (1858) recognized the fact that conjugation in *Spirogyra* is essentially the same as sexual reproduction in *Oedogonium* or *Vaucheria*, and he named the body produced by conjugation of two *Spirogyra* cells the *zygospore*. A union of two motile swarmers was first described by Pringsheim in 1870. He and all others who described the process during the next few years speak of it as a fusion of two zoospores to form an oospore or a zygospore.

The terms zygospore and oospore perpetuate the erroneous idea that fertilization results in the formation of a spore-like body. In 1877 DeBary and Strasburger gave a new interpretation of the phenomenon and proposed a new terminology. They called the two fusing cells *gametes* and named the fusion product the *zygote*. The cell producing the gametes was called the *gametangium*. DeBary and Strasburger restricted this terminology to the cases where the two gametes are of similar size, but they differentiated between a fusion of flagellated gametes (*planogametes*) and of nonflagellated gametes (*aplanogametes*). Five years later Falkenberg (1882) extended this concept by recognizing the gametic nature of eggs and antherozoids and substituting the term zygote for the term oospore. He distinguished between a fusion of similar and dissimilar gametes by calling the former *isogamy* and the latter *oogamy*.

Reproductive organs of red algae differ so markedly from those of other algae that they are given special names. At first, as with other algae, the reproductive structures were considered floral in nature. Thus, Ellis (1757) described the pedunculate flowers and catkins of a filamentous alga now referred to the red algae. During the period when reproductive organs were considered fruits, both C. A. Agardh (1823) and Greville (1830) noted that many algae now included among the red algae have two kinds of fruit and that the two are never borne on the same plant. One kind of fruit was called a *capsule*, the other kind a *granule*. Greville was the first to note that the granules are always ternately divided. When J. G. Agardh (1836) began using the name spore in connection with algae he called the ternate granule a *sphaerospore*. In 1842 Decaisne changed this name to *tetraspore*. Both J. G. Agardh and Decaisne thought that they were dealing with a spore divided into four parts or sporules and it was not until 1882 that Falkenberg called each of the four parts a tetraspore.

The distinctive type of reproductive organ that C. A. Agardh (1823) found in *Polysiphonia* and named the antheridium is now known to be a male reproductive organ. Derbès and Solier (1850) thought that the antheridia of certain red algae liberated flagellated reproductive bodies which they called antherozoids. When Bornet and Thuret (1867) showed that

these bodies of red algae lack flagella they called them *antheridial corpuscules* and this term was used until Schmidt (1883) thought them similar to *spermatia* of fungi and called them by that name. Later he (Schmitz *in* Schmitz and Hauptfleisch, 1896) suggested that the individual cell liberating a spermatium be called the *spermatangium* and that the name antheridium be reserved for the cluster of spermatangia.

In 1844 J. G. Agardh introduced the well-known term *cystocarp* as a substitute for the term capsule. For nearly a quarter of a century botanists had no difficulty in recognizing cystocarps but they had no idea of their nature. The nature of the cystocarp was first shown by Bornet and Thuret (1867) when they demonstrated that fertilization in red algae is effected by passive transportation of a male gamete (the antheridial corpuscule or spermatium) to a hair-like outgrowth which they designated as the *trichogyne*. They said that the trichogyne was borne at the apex of a cell, the *carpogonial cell*, terminating a special filament, the *trichophoric apparatus*. In 1883 Schmitz realized that this carpogonial cell is the female sex organ of red algae and named it the *carpogonium* because of the analogy to the oogonium of green algae.

Bornet and Thuret saw that fertilization was followed by development of the cystocarp and that this might involve cells other than the carpogonium. In an attempt to clear up matters they introduced the term *procarp* but this can hardly be considered a step in advance because even today phycologists are still trying to define the term. Most of the remaining terms applied to structures involved in the complicated development of cystocarps were proposed by Schmitz in 1883. Schmitz noted that certain cells adjacent to or remote from the carpogonium were densely filled with cytoplasm. These he called *auxiliary cells*, but he did not distinguish between those purely nutritive in function and those destined to take over the carpogonial function and produce carpospores. Kylin (1928) ended this confusion by calling the purely nutritive cells *nurse cells* and restricting the name auxiliary cell to those producing outgrowths bearing carpospores. Schmitz (1883) proposed the term *ooblastema* to designate the filamentous outgrowths from carpogonia and auxiliary cells. He used this name for two entirely different types of filament: those establishing a connection between carpogonium and auxiliary cell, and the carpospore-producing filaments growing from a carpogonium or from an auxiliary cell. Later he (Schmitz *in* Zerlang, 1889) restricted usage of the term ooblastema to connecting filaments between carpogonia and auxiliary cells, and gave the name *gonimoblast* to the carpospore-producing filaments. Special protective structures surrounding cystocarps are usually called pericarps or involucres. These names date back to the time when reproductive structures of algae were described in terms of floral morphology and serve as a constant reminder of old misconceptions concerning reproduction of algae.

Finally, there is the terminology used to describe the life cycle of algae. As is well known, Hofmeister (1851) described what he called an alternation of generations in bryophytes and pteridophytes. This phrase was first

used by the zoologist Steenstrup (1842) to describe the life cycle of certain coelenterates but it is not clear whether or not Hofmeister borrowed the phrase from him. Most botanists are not aware of the fact that the names now used to designate the two generations do not date from Hofmeister. He writes about "the first generation . . . destined to produce the sexual organs" and states that "the object of the second generation is to form numerous. . . . spores." Within a short time botanists began to call Hofmeister's first generation the sexual generation and his second generation the asexual generation. In 1884 DeBary named the asexual generation the *sporophyte*, and in 1891 Bower called the sexual generation the *gametophyte*.

Shortly after Hofmeister demonstrated the alternation of generations in archegoniates, botanists began to debate the question of the presence of a similar life cycle in algae. The first botanists to discuss this question tried to homologize the thallus of filamentous green algae with the sporophyte and the sex organs with the gametophyte. Interest in the question was revived in 1894 when Strasburger pointed out the difference in chromosome numbers of the two generations. Williams (1903), the first to apply this criterion to algae, found that sexual plants of the brown alga *Dictyota* are haploid and the asexual plants diploid. In speaking of the two generations he calls them gametophyte and sporophyte, a practice universally followed by all others who have found a similar life cycle among green and brown algae.

Application of the terms gametophyte and sporophyte to red algae is a more complicated matter and has been in accordance with the individual investigator's interpretation of the nature of the cystocarp. Oltmanns (1898) called plants bearing antheridia and carpogonia gametophytes and interpreted the cystocarp as a parasitic asexual generation which he called the sporophyte. He called the free-living plant producing tetraspores by the noncommittal name of tetrasporic plant and considered it an accessory generation of the gametophyte. Yamanouchi (1906), the first to study the chromosome cycle in a tetrasporic red alga, used the number of chromosomes as the criterion for differentiating between the two generations, and included both the cystocarp and the tetrasporic plant in the sporophytic generation. The terminology introduced by Church (1919) reconciles the conflict between the morphological and cytological viewpoints. He follows Oltmanns in considering the cystocarp a parasitic asexual generation and calls it the *carposporophyte* irrespective of whether it is haploid or diploid. In those red algae with a free-living tetrasporic plant he calls this the *tetrasporophyte*.

The foregoing account showing the inaccuracy of many morphological terms has not been written as a prelude to a plea for a revised terminology. Even if one could do the impossible and propose a terminology that would go unchallenged it would serve no real purpose because a botanist would have to know both the revised and the old terminology.

This historical survey has been written with two objectives in view. One

objective has been to interest other botanists in a subject that has long been a hobby of the writer, the original meaning of terms used in plant morphology. The second, and more important, objective is to point out the manner in which many terms in current use recapitulate development of knowledge of the nature of reproductive structures of algae; how some terms recall the period when reproduction of algae was thought to be identical with that of flowering plants; how other terms recall the period when reproduction of algae was first recognized as different from that in flowering plants; and how still other terms recall the period before a distinction was made between sexual and asexual reproduction of algae.

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3(2):225–267 FARLOWIA JULY, 1947

THE GENUS TYLOSTOMA IN INDIA

W. H. LONG AND SULTAN AHMAD

As most of the specimens of the genus *Tylostoma* discussed in this paper were collected from the Panjab Plains, we think it advisable to give data on location, climate, soil and topography of this region, so that our readers can get some idea of the conditions under which these species grew. These data were furnished by the junior author, Sultan Ahmad.

The Panjab occupies the extreme northwest corner of India and comprises nearly the whole region north of Sind and Rajuputana, and west of the Jamna River. In the north it extends beyond the great peaks of the Central Himalayas and embraces the Tibetan Valleys of Lahul and Spiti. On its southern border it encroaches upon the desert of Rajuputana. The main part of the province is a country of doabs (land between rivers) and deserts.

The province represents a great variety of physical features from the snow peaks and glaciers of the Himalayas to the sandy deserts of Bahawalpur; but the major portion forms part of the great alluvial plains of India.

The Panjab may conveniently be divided into the following areas, each of which has a characteristic climate and vegetation: 1. The Plains; 2. The Salt Range; 3. The Sub-Himalayan; 4. The Himalayan Tract.

Of these the Plains constitute the largest and by far the most important part of the Province. They consist of a vast rolling expanse of land characterized by extreme flatness, with a very gentle, almost imperceptible slope toward the southwest, in the direction of the flow of the rivers. At its highest point it is never more than 1000 feet, and at its lowest never more than 500 feet above sea level. The surface on the whole is almost unbroken, except some hillocks of gneiss near Tosham in Hissar and isolated rocks at Kirena, Chiniot and Sangla. The only eminences otherwise are low ridges of wind-blown sand and the "thehs" or mounds which represent the accumulated debris of ancient village sites. The whole area is drained by five rivers, the Jhelum, Chenab, Ravi, Beas and Sutlej. Between the rivers (the doab) there is usually a flat, alluvial plain covered with cultivated fields. During the rainy season the sandy bed of a stream becomes full from bank to bank, and the silt-laden waters spill over into the cultivated lowlands. Sometimes the river may leave its old bed and in a single night destroy miles of fertile fields, cutting for itself a new channel.

On the northwest the Panjab Plains end abruptly against the Salt Range and on the northeast stretch to the foothills of the Himalayas. On the east they fade imperceptibly into the Gangetic Plains. To the south of the Sutlej River, the land begins to rise gradually and becomes drier till it passes into the barren wastes of the Indian Desert.

CLIMATE

The climate is of the monsoon type which is characterized by the seasonal reversal of the winds. Three distinct seasons may be recognized: (a) the "cool dry" season, from mid-October to March; (b) the "hot dry" season from April to mid-June; (c) the "rainy season," from mid-June to mid-October.

The rains cease in the end of September. The days are still warm, but the skies are clear, the air dry, and the nights cool. In October and November the daily range of temperature is very wide, exceeding 30°F., and the fall at sunset very sudden. In winter small but valuable precipitation results from the passing of a series of small storms from the west. The clouds begin to gather before Christmas, but the rain often holds off till January. The central districts receive approximately 1 inch in each of the months January, February and March, mostly from this source. In winter during the nights the temperature on grass falls below 32°F. and for a couple of months there is hoarfrost 5–10°F. The heat begins to be unpleasant in April, and in May and June scorching winds blow and the temperature may rise to 110–120°F.

AVERAGE ANNUAL RAINFALL FOR THE DISTRICTS IN INCHES

Zone	*District*	*Rainfall*	*Zone*	*District*	*Rainfall*
North	Gujrat	28	South	Gujranwala	24
Central	Sialkot	35	Western	Lahore	21
or	Gurdaspur	35	Plain	Shahpur	14
	Hosiarpur	36		Sargodha	14
North	Amitsar	24		Jhang	10
Eastern	Jullunder	28		Sheikhupura	10
Plain	Ludhiana	28		Lyallpur	10
	Ambala	35		Montgomery	10
				Multan	7
Northwest	Rawalpindi	33		Muzaffargarh	6
Plain	Jhelum	26		Dera Ghazi Khan	6
	Attock	19			
	Mianwali	12	South	Karnal	30
			Eastern	Gurgaon	26
			Plain	Rohtak	21
				Hissar	16
				Ferozpur	21

The heat is somewhat relieved at times by dust storms accompanied often by rainfall. The monsoon "breaks" in the Panjab by the end of June and ends just after the middle of September. In the monsoon season, the climate is mild only on rainy days but there is great relief by the discontinuance of hot dry scorching wind. But the intense dry heat is healthier and to many less trying than the mugginess of the rainy season. The dust storms which used to be common have become rarer with the spread of canal irrigation in the Southwestern Plain.

It is mainly on a climatic basis that the Panjab Plains can be divided into 4 subregions:

1. *The Northeastern or North Central Plain.* It has a shorter and less severe cold weather than the Northwestern, an earlier and a heavier monsoon, but scantier winter rains. The total rainfall varies from 20–30 inches.

2. *The Northwestern Plain.* It has a longer and colder winter and spring. The total rainfall varies from 16–32 inches. The monsoon rains come late and are much less abundant than in the sub-montane zone. On the other hand the winter rains are heavier than in any part of the province.

3. *The Southwestern Plain.* It includes the driest parts with a rainfall from 5–15 inches. At Multan there are only about 15 days in the whole year on which any rain occurs.

4. *The Southeastern Plain.* Here again the rainfall averages between 20–30 inches, but varies very much from year to year, and the area often suffers from famine.

RAINFALL DURING WINTER AND SUMMER IN INCHES

District	*Monsoon Rain June-September*		*Winter Rain December-March*	*Annual Total*
Gurdaspur	26.94		6.70	35.80
Jullunder	19.56		4.12	25.35
Rawalpindi	19.88		7.35	31.8
Jhelum	13.99		4.58	20.93
Attock	11.99		5.70	20.64
Mianwali	5.96		2.44	9.92
Ambala	27.87		4.35	34.24
Karnal	18.44		2.74	22.67
Rohtak	17.60	av. for 6 yrs.	3.01 av. for 6 yrs.	21.00
Lahore	12.34		2.70	16.30
Lyallpur	8.22		1.66	10.99
Sheikhupura	9.00		1.80	12.00
Sargodha	9.78		3.09	14.64
Montgomery	7.16		1.66	9.55
Multan	4.16		1.08	5.84
D. G. Khan	3.23		1.25	5.40

VEGETATION

The vegetation differs a great deal in the different climatic zones enumerated above. In general when the rainfall drops below 40 or 30 inches it is too dry for the adequate growth of forests. In localities favored as regards soil and underground water supply, even where it is as low as 20 inches per year, good forests of *Dalbergia sissoo* and *Morus alba* are found. Such forests occur especially on the sides of the rivers. Where the rainfall drops below 20 inches the conditions approach those of semi-desert, xerophytic plants becoming important. The whole of the Southwestern Plain and a part of the Southeastern Plain shows this type of vegetation. The soil and climate are adapted to scrub jungle of drought resisting type.

The primitive forests of the Plains consist of *Tamarix articulata*, *Salvadora oleoides*, *Prosopis spicigera* and *Capparis aphylla*. These scrub forests or "Rakhs," which to a very large extent have been brought under cultivation, are fast disappearing from the scene as whatever was left of

them by the original cultivators has been cut for fuel and timber. The only fungus of note in these scrub forests is *Itajahya rosea*, growing near bases of *Salvadora oleoides*. The trees are very old and the leaves and vegetable debris accumulate near their bases, making an ideal habitat for this fungus. It grows there undisturbed from year to year, often in very large quantities.

Another good habitat for small fungi, mostly agarics, is the sides of the water courses. The Gasteromycetes growing on the sides of these are *Lycoperdon echinellum*, *Phallus celebicus*, *Simblum gracile*, and *Protubera maracuja*, in addition to some species of *Tylostoma*.

With the destruction of natural vegetation the unirrigated areas have been converted into bare, sandy wastes which are covered by annual or perennial grasses. These are the ideal places for the growth of numerous species of *Tylostoma*; in addition to these there are found *Geaster* sp., *Schizostoma laceratum* and var. *nigrum*, *Disciseda cervina*, *Simblum gracile* and many small agarics.

During monsoon rains these grassy areas serve as good grazing grounds for cattle. The upper layers of the soil are renewed every year by sand storms which deposit large quantities of sand from the adjacent areas; consequently these areas are at a higher level than the surrounding cultivated fields. Their level is responsible for their preservation in this state as they cannot be irrigated by canal water. In addition to the cultivated fields these sandy tracts are impregnated with salt to form "Kallar," as it is locally called. These saline patches are more or less devoid of any vegetation, excepting *Suaeda fructicosa* and *Salsola foetida*. The only fungus found beneath these bushes is *Schizostoma laceratum* var. *nigrum*.

With the advent of canals, however, the whole flora has undergone a marked change, being more or less entirely replaced by trees of *Acacia arabica*, *Dalbergia sissoo*, *Morus alba* and *Zizyphus jujuba*. Nothing can be said about the change which might have taken place in the fungous flora due to the same cause. It is certain that some of the species growing on the hills have every chance of migrating and settling if environmental conditions suit them. This is more likely to be the case in the sub-montane region where the conditions are not so extreme as lower down in the plains.

The sandy soils also have certain characteristic plants which avoid the less porous soil of the typical Rakhs. Examples of these plants are *Crotolaria burhis*, *Leptadenia spartium* and *Calligonum polygonoides*. The last plant has been seen only in the sandy desert area of the Bahawalpur State. The fungous flora consists of *Phellorina inquinans*, *Podaxon pistillaris*, *Tylostoma volvulatum*, *Terfezia leonis* and *Schizostoma laceratum*. We are sure that intensive collections in the desert regions would yield a large number of *Tylostomas* in due course of time. With the exception of the fungi mentioned above nothing is known about the fungous flora of the sand hills in the south which pass into the great Indian Desert. The junior author had a chance only once of collecting these in the Bahawalpur State.

The two most frequent species in the sandy cultivated fields are *Podaxon pistillaris* and *Lycoperdon pusillum*. These are collected in large quantities during the monsoon period for culinary purposes. The other edible species are *Phellorina inquinans* and *Terfezia leonis*. The former is sold in the Bazaars of Multan, and is also cut into small pieces, dried and stored for future use. *Terfezia leonis* is also kept in this condition and used as a luxury after the rains when the fresh plants are not available. The agarics are hated by the natives and never collected for any purpose whatsoever.

The water-logged areas have a typical aquatic vegetation, the only fungi are a number of agarics and a very unusual species of *Tylostoma* which is discussed later in this article.

SOIL

The main part of the country is a monotonous plain of fertile loam which is of light reddish color in some districts; interspersed with it are also found tracts of stiff clay and loose sand. In the Thal Desert, districts of Jhang, Multan and Hissar and the Bahawalpur State there is a vast expanse of sand forming low sand hills or dunes which keep shifting their position during the daytime.

Tracts impregnated with salts locally known as "Kallar" are widely distributed. The salts are usually chloride, sulphate and carbonate of sodium in varying proportions. These saline patches are usually more or less localized but sometimes occur over vast areas. During the rains these can be recognized by the absence of any kind of vegetation, but in winter the surface becomes covered with white incrustations of salt. Near Ladher in the Sheikhupura district this "Kallar" extends over several miles and water-logging is frequent. It is interesting to note this fact because many of the *Tylostoma* collections come from there. In certain parts the water-logging is a regular nuisance and actually threatens the prosperity of the Province. It is due to excessive use of canal water and defective drainage. More often the cause of water-logging, like the accumulation of salts in the soil ("Kallar") is caused by a hard bed of clay or kankar (argillaceous concretionary nodular limestone), which prevents the percolation of the surface water.

The sandy clay soil of the sandy wastes described above which are not brought under cultivation becomes hard excepting the superficial layer which is trampled over by the grazing animals and made loose by their hoofs. During the summer some soil is also deposited by the sand storms on these areas of waste land. The size of the *Tylostoma* depends on the depth of this superficial loose soil. Under these conditions even the largest species, *Tylostoma volvulatum*, assumes a small stature. We have strong evidence in favor of this view. In one spot the soil was levelled and a large amount removed and deposited on the sides of the fields over waste land nearby. After 2 years a very good crop of *T. volvulatum* was found growing there, some specimens measuring about 20 cm. in total height. When

this area was visited after a number of years the whole soil was covered with small grass and the few specimens of *Tylostoma volvulatum* found measured about 5–8 cm. in height. This change had occurred in a few years, due, apparently, to the hardening of the lower layers of the soil by the gradual percolation of rain water and the trampling of the grazing animals. The same spot was brought under cultivation during the "grow more food" campaign, and as the level was very high as compared to the surrounding area, the rain water could easily drain off into the adjacent soil. The result was that no crop was possible but the ploughing had done a positive good to the soil and the next year very large specimens of *T. volvulatum* were again found growing there. In sandy places also the same phenomenon is observed, the length of the stipe depending on the depth at which the button stage lies. In the beginning the carpophore may start its growth near the surface of the soil but during dust storms, which are very frequent in these places, they may get buried very deep in the sand, and then the stipe elongates enough to expose the peridium above the surface of the soil. The junior author easily proved this fact by putting buttons of *T. volvulatum* at different depths in moist sand in his laboratory. He found that the plants invariably came above the surface of the soil or at least cracked the layers of soil lying above. Further exposure is affected possibly by the shifting of the soil by wind.

CLIMATIC DETAILS OF PLACES LYING OUTSIDE THE PANJAB FROM WHICH *Tylostoma* SPP. HAVE BEEN COLLECTED

Mussoorie (30°28′N., 78°10′E.)

Height above sea level ..... 6000–8000 feet.
Average annual rainfall ..... 110 inches.

It is situated upon one of the outer ranges of the Himalayas which lie to the north of Dehra Dun. The mean maximum temperature ranges from 40°F. to 45°F. and the mean minimum temperature between 30°F. to 35°F. The mean maximum temperature in June, the hottest month, is 75°F. and the mean minimum 60°F. Snow falls in the winter.

Dehra Dun (30°20′N., 78°6′E.)

Height above sea level ..... 2300 feet.
Average annual rainfall ..... 85.5 inches.

It is situated in the midst of a mountain valley 2300 feet above sea level. It enjoys a great reputation as a hill resort.

Delhi (28°39′N., 77°16′E.)

Height above sea level ..... 714 feet.
Average annual rainfall ..... 26.24 inches.

The capital of India lies inside a tiny Province on the west bank of the river Jamna and hence in the Gangetic Plain. On the west there is a low ridge which is merely a spur of the Arawalli Range.

Madras (13°4′N., 18°17′E.)

Height above sea level ..... 67 feet.
Average annual rain fall ..... 50 inches.

Madras lies in the coastal plain of South India, which consists mainly of alluvium. Climatically the whole region is quite distinct from the rest of India. During May to September no part receives more than 20 inches of rain. On the other hand November and December are the wettest months of the year when the remainder of India is almost rainless. The cloudless skies which prevail from January to June result in higher temperatures, and there is the annual range of 14°F. The winters are much warmer and a comparison with Northern India is interesting.

Pusa (26°3′N., 85°30′E.)

Height above sea level ..... 200 feet.
Average annual rainfall ..... 50–55 inches.

It lies in the Middle Ganges Plain in the Bihar Province beside the river Gandak, a tributary of the Ganges. The climate is less extreme than in the Upper Ganges Plain or the Panjab, but it is still cold enough in January (average of 68°F.). In the hot season the scorching winds blowing down the Ganges Valley are still felt, but the heat is less intense than in the Panjab or upper Ganges. In the rainy season the river frequently overflows and causes widespread floods depositing quantities of silt and mud on the surrounding land.

Skardu (35°3′N., 75°6′E.)

Old capital of Baltistan, 7250 feet above sea level.

It is situated in a sandy basin lying on both sides of the Indus River and more than 5 miles in width. The climate of Baltistan is very severe and most of the rivers are frozen in winter. On the other hand near the river on Skardu Plain the heat is intense in July and August. The rainfall is very scanty throughout the area.

Nilgiris

The Nilgiris are on a plateau some 700 square miles and 6500 feet high. This plateau is much broken by high ridges and rocky summits. It is located south of Mysore State and forms the southern end of the Western Ghats. Ootacamound in these hills is a favorite health resort for Europeans, and it is very probable that our plant *Tylostoma exasperatum* was collected in the vicinity of this station. It has an average rainfall of 48 inches and rather mild climate.

The junior author finds that all species growing in sandy soil or sandy loam have a radicating base, while the plants growing in clay soil or in leaf debris have a bulbous base; as the sandy soil is more porous and retains no water, the plants develop the root-like organs for the absorption of water from the lower layers where it is available. The hyphae growing

to form bundles appear to be much more efficient organs of conduction as compared to single hyphae. When they are long and branched they also serve to fix the plants firmly in the loose sandy soil. In the pure clay soil the formation of a rhizomorph is very difficult due to the hard nature of the soil, and indeed it appears to be unnecessary as both the functions enumerated above can be efficiently performed by the simple hyphae. The clay soil can hold and retain a large amount of water and is hard and compact and can serve for the fixing of the plant even when a few hyphae are developed. The same thing holds good for the humus soil which can also retain and absorb large quantities of water. The half-decomposed leaves, if present, further minimize the chance of rhizomorphs. There is a possibility that the hyphae may spread over and in the leaf debris instead of forming radicating bases.

In studying the species of *Tylostoma* from the Panjab Plains, the senior author was amazed at the following peculiarities in these collections:

1. The preponderance of small or tiny plants which makes the Panjab seem a land of midget *Tylostomas*. There is nothing like it in the United States.
2. The small number of medium size and large species, only 2 or 3.
3. The absence of plants with well-developed fibrillose mouths.
4. The absence of any well-developed volvas on most of the collections.
5. The large number of specimens with radicating bases.
6. The large number of plants that are covered with dried dirt or clay.

Long (1944, 1947) proposed the following subdivisions for the exoperidia and for the mouths of *Tylostoma*. He divided the exoperidium into two distinct zones, a basal band or peridial sheath enclosing the base of the endoperidium, and the remaining portion consisting of the exoperidium proper. This *peridial sheath* is a tough layer of agglutinated hyphae and sand, firmly attached to the base of the endoperidium and usually differing in texture and composition from the exoperidium proper.

The exoperidium proper may occur in one of 4 different types of structure: 1. A granular type consisting of hyphae and sand; 2. A semi-membranous structure; 3. A permanently membranous exoperidium; 4. The hyphal type which may be split off from the granular type when the granular portion is very thin or evanescent and when the hyphal portion consists of an amorphous layer of flocci covering the endoperidium and firmly attached to it. This fourth type is usually covered with brownish warts. Under this hyphal type come the following species: *Tylostoma verrucosum*, *T. dumeticola*, *T. Bonianum*, *T. Leveilleanum*, *T. exasperatum*, *T. mussoorieense* and *T. crassipes* (this without any warts).

The mouths may be as follows: tubular, semi-tubular, fibrillose, subfibrillose, indefinite, operculate and valvate. The tubular, fibrillose and indefinite need no description as they are well-established forms, but the others need to be defined. The subfibrillose are those mouths which have very small fibrils and often merge into the indefinite forms, that is, some

heads may show a few fibrils while other heads in the same collection may have naked indefinite mouths. The semi-tubular forms are those mouths with a definite elongated very narrow erect border; the valvate type are those which open in a definite stellate valvate manner, of which *T. exasperatum* is a good example. The operculate mouth consists of a torn aperture, linear or elliptic in shape, folded backward as an irregular lid on one side of the orifice and becoming lacerate and indefinite with age and weathering. This operculate type has, so far, been found only in India.

The following are the species discussed in this article, with photographs and technical descriptions of each:

Species with tubular mouths: *Tylostoma mussooriense*, *T. hygrophilum*, *T. evanescens*, *T. sedimenticola*, *T. xerophilum*, *T. subsquamosum*, *T. amnicola*, *T. balanoides*, *T. pluriosteum*, *T. albocretaceum*, *T. psilophilum*, *T. inonotum*, *T. cineraceum*.

Species with subfibrillose to indefinite mouths: *T. parvissimum*, *T. membranaceum*, *T. puncticulosum*, *T. vulgare*.

Species with valvate mouths: *T. exasperatum*, *T. Wightii*.

Species with operculate mouths: *T. exitum*, *T. operculatum*.

Species with indefinite mouths: *T. crassipes*, *T. albiceps*, *T. perplexum*, *T. volvulatum*; making a total to date of 25 species in India, of which 3 have hyphal exoperidia, 3 membranous, 3 semi-membranous and the balance granular exoperidia.

KEY TO THE SPECIES OF *TYLOSTOMA* IN INDIA

1. Exoperidium hyphal 2
1. Exoperidium membranous 3
1. Exoperidium semi-membranous 4
1. Exoperidium granular 5
2. Mouth tubular, sporocarp warty, brown.....**1. T. mussooriense**
2. Mouth valvate, sporocarp warty, spores strongly digitiform, with halo **19. T. exasperatum**
2. Mouth indefinite, naked, sporocarp not warty ...**22. T. crassipes**
3. Mouth subfibrillose to indefinite 6
3. Mouth tubular, plants small, spores verruculose .....**6. T. xerophilum**
4. Plants small, mouth tubular, sporocarp persistent, spores echinulate **4. T. sedimenticola**
4. Plants medium size, mouth tubular, sporocarp deciduous, spores verruculose **8. T. balanoides**
4. Plants large, volva prominent, mouth indefinite...**25. T. volvulatum**
5. Mouths several, subtubular, spores verruculose.....**2. T. pluriosteum**
5. Mouth tubular, plants small, spores smooth.....**3. T. evanescens**
5. Mouth subtubular, plants medium size, wet habitat....**5. T. hygrophilum**
5. Mouth tubular, plants medium size, spores strongly echinate with a halo **7. T. subsquamosum**
5. Mouth tubular, stem volvate, white, spores smooth.....**11. T. albocretaceum**
5. Mouth tubular, plants medium size, drab, spores smooth **12. T. cineraceum**

5. Mouth tubular, plants small, stems brown, endoperidium avellaneous, spores verruculose to smooth.....**10. T. amnicola**

5. Mouth subfibrillose, plants medium size, endoperidium wood brown, stipe striate to sulcate, spores smooth .....**15. T. vulgare**

5. Mouth subfibrillose, plants very small, endoperidium dingy white, stipe rugose to smooth, spores smooth.....**14. T. puncticulosum**

5. Mouth operculate, plants very small, spores strongly verruculose **20. T. exitum**

5. Mouth operculate, plants small, spores smooth.....**21. T. operculatum**

5. Mouth indefinite, plants medium size, sporocarp white, stipe tilleuil buff, spores verrucose .....**23. T. albiceps**

5. Mouth indefinite, plants small, stipe pecan brown, spores verruculose **24. T. perplexum**

5. Exoperidium granular-hyphal 7

6. Plants small, spores echinulate.....**16. T. parvissimum**

6. Plants medium size, spores smooth.....**17. T. membranaceum**

7. Mouth tubular, plants very small, endoperidium brown, spores echinulate **9. T. psilophilum**

7. Mouth tubular, short, exoperidium brown, persistent, spores verruculose **13. T. inonotum**

7. Mouth valvate, endoperidium papyraceous, brown, spores verrucose **18. T. Wightii**

1. Tylostoma mussooriense P. Henn., Hedwigia **40**: 337. 1901.

FIGURE 1

Sporophore having sporocarp, stipe and bulbous base. *Sporocarp* subglobose, 5–6 mm. high by 6–8 mm. wide, firmly attached to stem apex. *Exoperidium* hyphal, having a thin layer of hyphae, with very small flattened warts, Hays brown to burnt umber, tardily and irregularly deciduous over top of the peridium, leaving a scarred surface. *Peridial sheath* similar to the exoperidium and continuous with it, persistent, covered with small warts same color as exoperidium. *Endoperidium* rough from the adhering fragments of the exoperidium and from the scars left by the shedding of the warts, light ochraceous buff, membranous. *Mouth* small, about 1 mm. wide, slow to open, when unopened with a pointed central umbo. *Collar* inconspicuous about 1½ mm. from stem. *Stipe* very slender, tapering upward to apex, terete, with small more or less appressed scales which are more prominent on upper part of stem, walnut brown, 2–6½ cm. tall by 1½–2 mm. thick at top, by 2–3 mm. thick at base. *Bulb* 5–10 mm. thick, of hyphae and sand. *Volva* none. *Radicating base* none. *Gleba* cinnamon. *Capillitium* hyaline, rarely septate, not swollen at nodes. *Spores* subglobose, 3.8–4.95 μ in diameter. *Epispore* verrucose, no halo.

Habitat: Solitary or in groups in gravelly soil on the eastern slopes of bare rocks.

Distribution: Mussoorie-Garhwal Road, 7000 ft. elevation, July 20, 1940, *S. Ahmad*, 8 plants Herb. Ahmad no. *425*, 2 of these now in Herb. Long, no. *11087*. This species was first collected by William Gollan from Mussoorie, Arnigardh on August 9, 1900. This is the first time that it has

been found again and in the same general locality. It is the only *Tylostoma* occurring at this high altitude with an annual rainfall of 110 inches.

This species is close to *Tylostoma verrucosum* Morgan but after a careful comparison of the type material of the 2 species we have decided that they are not the same.

2. Tylostoma pluriosteum sp. nov.

FIGURE 2

Sporocarpo depresso-globoso, 6–8 mm. alto, 14–16 mm. lato. *Exoperidio* pulverulento, toto secedente in aetate. *Endoperidio* membranaceo, gilvo usque albido. *Oribus* subtubulatis singulis usque pluribus. *Stipite* 5–32 mm. alto, 3–5 mm. crasso. *Sporis* subglobosis, 4–5.5 μ. *Episporio* verruculoso.

Sporophore having sporocarp, stipe and slightly swollen base. *Sporocarp* depressed-globose, 6–8 mm. high by 14–16 mm. wide, firmly attached to stem apex. *Exoperidium* granular, deciduous on some plants to only partially so on others. *Peridial sheath* a broad band of hyphae and sand, 4–5 mm. wide, persistent. *Endoperidium* membranous, pitted on top in some plants, and rough in others from the adhering dirt, light buff to dingy white. *Mouth* subtubular, definite with or without a distinct raised collar-like margin, from one to four or more on each head; young freshly emerged heads often with mouths covered at first with raised distinct pointed umbos which when broken off leave the white throats (Fig. 2a) of the mouths exposed. *Collar* wide, about 2 mm. distant from stem. *Stipe* 5–32 mm. long by 2–5 mm. thick; base bulbous and radicating. *Bulb* 6 mm. thick. *Volva* none. *Gleba* ferruginous. *Capillitium* hyaline, lumen small, walls medium to thin, ends of threads at septa rounded, not swollen. *Spores* globose to subglobose, 4–5.5 μ in diameter. *Epispore* verruculose.

Habitat: Solitary or caespitose in sandy soil.

Distribution: Sheikhupura District, Ladhar, *S. Ahmad*, September 8, 1944, 2 plants in Herb. Ahmad no. *1282* **type.** Gujranwala District, Gakkhar, August 12, 1944, 6 plants in Herb. Ahmad no. *1280*. All the mouths in this last collection were immature when collected, having pointed umbos which later showed as mouths when the points were broken off.

3. Tylostoma evanescens sp. nov.

FIGURE 3

Sporocarpo ovato vel subgloboso, 5–9 mm. alto, 5–12 mm. lato. *Exoperidio* granuloso, haud toto secedente. *Endoperidio* membranaceo, albo aetate cinnamomeo. *Ore* tubulato, integro, prominulo. *Stipite* 0.5–2.7 cm. alto, 1–3 mm. crasso, tenui, brunneo. *Sporis* subglobosis, 3.7–5.2 μ. *Episporio* levi.

Sporophore having sporocarp, stipe and radicating base. *Sporocarp* ovate to subglobose, 5–9 mm. high by 5–12 mm. wide, firmly attached to stem apex. *Exoperidium* granular, persistent or partially deciduous in age. *Peridial sheath* persistent, of hyphae and dirt, 2–4 mm. wide, usually covered with dry clay. *Endoperidium* membranous, white when fresh, becoming cinnamon with age, often pitted, generally mottled due to ad-

hering patches of the exoperidium, this probably depending on the frequency of rainfall after the plants elongate. *Mouth* tubular, strongly projecting. *Collar* inconspicuous, about 1 mm. distant from stem. *Stipe* 0.5–2.7 cm. long by 1–3 mm. thick, slender, weak, often broken near or in the socket, even, rarely with appressed scales or smooth or with adhering grains of sand, usual size 1–1½ cm. long by 1–½ mm. thick, often striate, terete, cinnamon to sayal brown. *Radicating base* prominent, often with roots 4–8 mm. long. *Gleba* ferruginous. *Capillitium* branched, hyaline, 3.2–6.5 μ thick, usually narrow and strongly swollen at septa (Fig. A 1). *Spores* globose to subglobose, subhyaline to dilute yellow, 3.7–5.2 μ in diameter, mean 5.25 μ. *Epispore* thin, smooth.

Habitat: Solitary in open sandy wastes, covered with a scattering scanty growth of perennial grasses, especially *Eleusine flagellifera, Dactyloctenium scindicum* and *Cyperus conglomeratus.*

Distribution: Rohtak District, Rohtak, *S. Ahmad*, April 10, 1939, 148 plants Herb. Ahmad, no. *254*, 16 of these are now in Herb. Long no. *10259;* April 25, 1939, 193 plants Herb. Ahmad no. *293*, 13 of these are now in Herb. Long, no. *11144* **type.** Sangla Hill, September 19, 1936, 8 plants in Herb. Long. no. *11154* (no. *28* Herb. Ahmad). Sheikhupura District, Ladhar, July 1938, *S. Ahmad*, 2 plants in Herb. Ahmad no. *318*; August 20, 1942, 56 plants Herb. Ahmad. no. *588*, 6 of these now in Herb. Long no. *11124;* August 6, 1944, 48 plants Herb. Ahmad, no. *1276*, 23 of these now in Herb. Long no. *11133*; July 7, 1945, 42 plants Herb. Ahmad, no. *1345*, 10 of these now in Herb. Long no. *11103*; July 15, 1945, 31 plants Herb. Ahmad no. *1402*, 16 of these now in Herb. Long, no. *11105*. Gujranwala District, Gakkhar, *S. Ahmad*, July 10, 1942, 110 plants in Herb. Ahmad, no. *587*; July 7, 1941, 120 plants in Herb. Ahmad no. *590*. Gurdaspur District, Jaggatpur, *S. Ahmad*, August 1937, 2 plants in Herb. Ahmad no. *389*; September 10, 1941, 12 plants in Herb. Ahmad no. *625*. Delhi Ridge near Delhi, on way to the Imp. Agric. Institute, *S. Ahmad*, July 22, 1943, 8 plants in Herb. Ahmad, no. *1278*. Four miles north of Sahkot, near the village of Sathyali, *S. Ahmad*, September 13, 1945, 60 plants Herb. Ahmad no. *1456*, 12 of these now in Herb. Long no. *11123*. Shahkot, *S. Ahmad*, July 1938, 11 plants in Herb. Ahmad no. *1295*. Sheikhupura District, Ladhar, *S. Ahmad*, August 31, 1945, 22 plants Herb. Ahmad no. *1445*, 7 of these now in Herb. Long, no. *11114*; August 10, 1936, 18 plants Herb. Ahmad no. *314*, 4 of these now in Herb. Long, no. *11118;* September 20, 1941, 34 plants Herb. Ahmad no. *591*, 4 of these now in Herb. Long, no. *11150*; August 1936, 6 plants in Herb. Long (Ahmad no. *591a*), no. *11120*. Ladhar, *S. Ahmad*, August 1940, 8 plants in Herb. Ahmad no. *577*; August, 1939, in Herb. Ahmad 4 plants no. *1292*; August 16, 1945, in Herb. Ahmad 3 plants no. *1406*.

This species appears in large numbers after the first showers of the monsoon in July, or in August if the rains are late. At this time the grasses are merely in the form of small knots without any trace of life and so the fungus, although very small in size, cannot be easily over-

looked. It becomes difficult to find late in the season as the grasses which were once insignificant now overshadow the fungus, even if a diligent search is made; most of the individuals are found with their peridia broken off from the stipes by the subsequent heavy showers.

It is a very common plant in the Panjab Plains, occurring in sandy wastes about the villages, left out when the rest of the land was brought under cultivation and irrigated by canals. As these areas are being rapidly brought under cultivation, this species is becoming scarce day by day. After a few years it is bound to become more or less extinct, at least in the Panjab, hence the name *Tylostoma evanescens* used in this paper.

Ahmad in his first paper (1939) referred it to *Tylostoma occidentale* Lloyd but later collections show some additional features not mentioned therein. This species has been compared by Long with the type material of *T. occidentale* Lloyd and found not to be that species. Dr. Coker suggested that it might be a small form of *T. albicans* White, while Dr. Cunningham says it resembles in its smooth spores and tubular stoma, *Tylostoma Leslei* Van der Bijl from South Africa.

4. Tylostoma sedimenticola sp. nov.

FIGURE 4

Sporocarpo globoso, 6–8 mm. alto, 8–10 mm. lato. *Exoperidio* semi-membranaceo nec toto secedente. *Endoperidio* membranaceo, albicanti. *Ore* tubulato integro, prominente. *Stipite* brevi, 8–20 mm. alto, 1:5–2 mm. crasso, brunneo, non squamuloso, striato. *Sporis* globosis vel ellipticis, 3.3–4.5 μ. *Episporio* tenui, echinulato.

Sporophore having sporocarp, stipe and radicating base. *Sporocarp* globose, 6–8 mm. high by 8–10 mm. wide, firmly attached to the stem apex. *Exoperidium* semi-membranous, more or less deciduous. *Peridial sheath* a sand-hyphae band, 2–3 mm. wide, persistent. *Endoperidium* membranous, dingy white to pinkish buff, smooth or rough from fragments of the exoperidium. *Mouth* tubular, small, strongly projecting. *Collar* inconspicuous, 1–2 mm. from stipe. *Stipe* 8–20 mm. long by 1.5–2 mm. thick, cortex peeling, not scaly, striate, cinnamon. *Radicating base* pronounced. *Gleba* ferruginous. *Capillitium* hyaline sparingly septate, septa swollen, 3.8–6.4 μ thick. *Spores* globose to elliptical 3.3–4.5 μ in diameter, average size 3.8 μ thick, subhyaline. *Epispore* thin, echinulate but echinules not very distinct (Fig. A 5).

Habitat: Solitary in sandy loam (not in leaf debris) near banks of the river Beas. The banks of this river are covered with a thick growth of *Tamarix dioica, Saccharum spontaneum* and *S. munja*. The plants grow in the loam under *S. munja* Roxb.

Distribution: Gurdaspur District, Jaggatpur, a small village on the banks of the river Beas, 12 miles from Gurdaspur, August 1937, 22 plants Herb. Ahmad, no. *280*, 7 of these now in Herb. Long, no. *11117* **type;** Ahmad no. *280a*, August 1938, 1 plant in Herb. Long no. *11145*; Sept. 10, 1941, 12 plants Herb. Ahmad, no. *623*.

One feature of the soil under consideration is that it is annually covered

by a thick layer of silt; this particular place is in the submontane region with a large annual amount of rainfall.

Previously described by Ahmad (1939) as *Tylostoma pygmaeum*.

5. Tylostoma hygrophilum sp. nov.

FIGURE 5

Sporocarpo depresso-globoso, 5–12 mm. alto, 5–19 mm. lato. *Exoperidio* pulverulento, nec toto secedente. *Endoperidio* albido, aetate brunneo, papyraceo. *Stipite* 2–7 cm. alto, 2–5 mm. crasso, albido aetate cinnamomeo. *Ore* subtubulato, brevi. *Sporis* subglobosis vel ellipticis 4.5–5.2 μ. *Episporio* levi.

Sporophore having sporocarp, stipe and slightly bulbous base. *Sporocarp* depressed-globose, often concave beneath, 5–12 mm. high by 5–19 mm. wide, firmly attached to stem apex. *Exoperidium* granular, consisting of hyphae and clay partially washed off by rains in mature plants, finally completely deciduous in age. *Peridial sheath* a layer of hyphae and clay, irregular, 3–5 mm. wide, persistent. *Endoperidium* white to pinkish buff, aging to cinnamon to wood brown, papyraceous, very thin, usually much torn, rough from adhering patches of clay. *Mouth* subtubular, very weak, usually central and circular but often excentric on head, many elliptic, with very slightly raised margins, tube rarely 1 mm. high, 2 plants with 2 mouths each and 1 plant, out of several hundred plants examined, with 3 mouths. *Collar* evident, inside wall vinaceous cinnamon, 3–4 mm. from stem, often pendent around stem and fimbriate. *Stipe* rather stout, rarely straight, usually more or less crooked, sometimes tortuose, 2.4–7.2 cm. high, usual size 3–4 cm. high, 2–5 mm. in diameter, even or slightly tapering upward, strongly striate to sulcate, white when fresh aging to cinnamon, cortex rugose to appressed, scales often peeling. *Bulb* formed of white mycelium and clay. *Gleba* cinnamon. *Capillitium* hyaline, lumen often none, branched, septa very slightly swollen (Fig. A 2). *Spores* globose to subglobose to ellipsoid, subhyaline to ochraceous, 4.5–5.2 μ, mean 4.7 μ in diameter. *Epispore* smooth, thin.

Habitat: Gregarious or usually caespitose in dense clusters, in thick growth of Doob grass (*Cynodon dactylon* — Bermuda grass in U.S.A.), in swampy places and in water-logged areas.

Distribution: Sheikhupura District, Ladhar, *S. Ahmad*, September 22, 1937, 44 plants Herb. Ahmad no. *250*, 4 of these now in Herb. Long no. *10260*; August 4, 1944, 28 plants in Herb. Ahmad, no. *1277*; September 1937, 169 plants Herb. Ahmad no. *1287*, 15 of these now in Herb. Long no. *11104*; August 2, 1945, 45 plants Herb. Ahmad no. *1350*, 19 of these now in Herb. Long. no. *11102*; August 26, 1945, 26 plants Herb. Ahmad no. *1430*, 10 of these now in Herb. Long no. *11131*; September 2, 1945, 130 plants Herb. Ahmad no. *1446*, 12 of these now in Herb. Long no.

Figs. 1-5. *Tylostoma*, × 1: **1,** *T. mussooriense* from **type; 1 a,** *T. mussooriense*, 2 plants from type locality; **2,** *T. pluriosteum*, 6 plants; **2 a,** *T. pluriosteum*, showing white throats where umbos have been broken; **3,** *T. evanescens*, 4 plants; **4,** *T. sedimenticola*, 3 plants; **5,** *T. hygrophilum*, 6 plants.

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4
a
2
a
1

11119, **type**; August 16, 1945, 13 plants Herb Ahmad no. *1406*; August 1944, 25 plants Herb. Ahmad, no. *1492*. Sargodha, *S. Ahmad*, August 12, 1939, 20 plants in Herb. Ahmad no. *576*. Qila Sattar Shah, Sheikhupura District, *S. Ahmad*, September 29, 1941, 5 plants in Herb. Ahmad no. *624*. Sangla Hill, *S. Ahmad*, (his no. *6*) 24 plants in Univ. N. C. Herb., and 20 plants (Ahmad no. *6*) in Herb. Long. no. *11158*; *S. Ahmad*, 2 plants in Univ. N. C. Herb. (no. *30*. Herb. Ahmad) and 3 plants in Herb. Long, no. *11155*, (Ahmad no. *30*). Bihar Province, Pusa, *E. J. Butler*, July 1906, (his no. *636*) 10 plants, now in Lloyd Myc. Coll. no. *53173*; July 25, 1906, (Butler's no. *640*), 6 plants now in Lloyd Myc. Coll. no. *53172*.

This is one of the commonest species in the Panjab Plains, differing from all others in its mode of growth and habitat. It is nearly always found in waterlogged or low areas where the rain water remains standing for a long time, especially on the margins of cultivated fields under water due to the rise in the level of the subsoil water during the rainy season. The plants occur in dense clusters among the thick Doob grass; the whitish peridia only visible from above. The length of the stems apparently depends on the height of the grass in which it is growing. The basal mycelial threads are white and abundant, binding the clay soil into big balls around the bases of the sporophores. This species is also covered with water completely during the monsoon rains and at this time the spores, loose heads and plants can be carried by the water, thus assisting in distributing the spores. This is quite a contrast to the usual wind-disseminated spores of our common species of *Tylostoma*. This is the only species known to us that normally grows in dense grass or other vegetation; usually when a *Tylostoma* is found on grassy areas in the United States, it grows in open spaces in the grass.

This species was identified by Dr. W. C. Coker as either *Tylostoma albicans* White or *Tylostoma MacAlpinianum* Lloyd and listed by Ahmad (1939) as *Tylostoma MacAlpinianum* and as *Tylostoma albicans* by Cunningham.

6. Tylostoma xerophilum Long, Mycologia **38:** 85–87. 1946.

FIGURE 6

Sporophore having sporocarp and stipe. *Sporocarp* subglobose 4.5–5 mm. high by 6–7 mm. wide, firmly attached to stem apex. *Exoperidium* strongly and permanently membranous, dehiscing in large patches and strips from above downward, outer surface Roods brown, rough from adhering dirt, inner surface pinkish buff, drying to a thin very fragile membrane. *Peridial sheath* a thin irregular band, membranous, 2–3 mm. wide, semi-deciduous. *Endoperidium* pinkish buff, papyraceous, smooth. *Collar* inconspicuous with a lacerate very short margin. *Stipe* 1–2 cm. long, rather stout, 2–3 mm. thick, even, rarely breaking, slightly flattened on one plant, avellaneous. *Volva* none. *Radicating base* none. *Bulb* none. *Gleba* ferruginous. *Capillitium* hyaline, slender, septate, septa

numerous, strongly swollen and rounded at nodes. *Spores* globose, 4.5–6.6 μ in diameter, mean 5.5 μ. *Epispore* walls medium thick, subhyaline to yellowish, verruculose.

Habitat: Solitary or in groups in soil covering rocks.

Distribution: Kirana Hills, near Sargodha, April 1936, *S. Ahmad*, 4 plants Herb. Ahmad, no. *294*. Central Provinces, Umaria, August 1942, *S. M. Sayadain*, 1 plant in Herb. Ahmad no. *589*.

This description was drawn from the Indian material listed above. It differs in some minor details from the original description of this species from Arizona described by Long (1946), but it is too close in all major characters to separate it from this American plant.

7. Tylostoma subsquamosum sp. nov.

FIGURE 7

Sporocarpo globoso usque depresso-globoso, 5–10 mm. alto, 7–11 mm. lato. *Exoperidio* pulverulento, ex parte secedente. *Endoperidio* membranaceo, nec toto levi, brunneo. *Ore* tubulato, brevi. *Stipite* 1–4 cm. alto, 2–3 mm. crasso, subsquamuloso, brunneo usque avellaneo. *Sporis* subglobosis vel ellipticis, 4–5.6 μ. *Episporio* prominenter spinoso, halone alba cincto.

Sporophore having sporocarp stipe and slightly swollen base. *Sporocarp* globose to depressed-globose, 5–10 mm. high by 7–11 mm. wide, firmly attached to stem apex. *Exoperidium* granular-hyphal, partially deciduous on upper half, walnut brown. *Peridial sheath* an irregular band, about 3 mm. wide, similar to exoperidum, persistent. *Endoperidium* membranous, cinnamon to vinaceous cinnamon, mostly covered by the exoperidium. *Mouth* tubular, short, about 1 mm. wide, conspicuous. *Collar* inconspicuous, about 1–2 mm. from stem. *Stipe* 1–4 cm. long by 2–3 mm. thick, with slightly spreading scales, especially near the peridium, peeling off, pecan brown to avellaneous, terete, often curved. *Volva* none. *Radicating base* none. *Gleba* cinnamon. *Capillitium* hyaline, branched, septa rather common, transverse, oblique or with rounded ends, swollen, or only slightly swollen or not at all. *Spores* ellipsoid to globose, 4.1–5.6 μ, mean 4.9 μ. *Epispore* medium thick, strongly echinulate with rather blunt spines. walls brown and spines hyaline to brown, with halo.

Habitat: In sandy soil, not under trees or in leaf debris.

Distribution: Gurdaspur District, Jaggatpur, *S. Ahmad*, August 1938, 4 plants in Herb. Ahmad no. *258* **type**. Dehra Dun, on flower pot, September 11, 1905, *E. J. Butler*, (his no. *646*), 1 plant from Herb. Crypt. Ind. Orient, now in Lloyd Myc. Coll. no. *4488*.

These 2 collections were compared with authentic material of *Tylostoma squamosum* from Hungary determined by Hollós, and from France, determined by Boudier, but there were too many differences. The specimens from India are too small, differing in color and in glebal characters from *T. squamosum*. The 4 plants from Jaggatpur were listed by Ahmad (1939) as *Tylostoma squamosum*.

8. Tylostoma balanoides sp. nov.

FIGURE 8

Sporocarpo oblongo vel subgloboso, 13–15 mm. alto, 11–20 mm. lato, facile ab apice stipitis secedente. *Exoperidio* semi-membranaceo, toto secedente aetate. *Endoperidio* membranaceo, levi, gilvo vel sordide albo. *Ore* tubulato, prominente, integro. *Stipite* 18–35 mm. alto, 3–5 mm. crasso, striato, brunneolo. *Sporis* globosis vel subglobosis, 4.2–4.9 μ. *Episporio* verruculoso.

Sporophore having sporocarp, stipe and radicating base. *Sporocarp* oblong to subglobose, 13–15 mm. high by 11–20 mm. wide, easily separating from stem, usually found on the ground. *Exoperidium* semi-membranous, completely deciduous in age. *Peridial sheath* very prominent, a heavy irregular band of hyphae and soil 2–10 mm. wide, persistent, with the peridium standing in it like an acorn in its cup. *Endoperidium* smooth in age, membranous, cream buff to dingy white. *Mouth* tubular, strongly projecting, margin brittle often breaking off, circular to oval, small about 1 mm. diameter, 1 head having a big central mouth with a small side mouth near the top of the peridial sheath. *Collar* inconspicuous, 2–3 mm. from stem. *Stipe* 18–35 mm. long by 3–5 mm. thick even or slightly tapering upward, brownish, striate and white under the peeling cortex. *Volva* none. *Radicating base* small. *Gleba* cinnamon. *Capillitium* hyaline, unevenly thick, lumen small or none, septa transverse, slightly or not swollen at the nodes (Fig. A 4), branches few, 4–7 μ thick, often flaccid. *Spores* subglobose, uniguttulate, some apiculate, 4–5 μ thick. *Epispore* verruculose.

Habitat: Solitary or gregarious in open, unshaded sandy soil.

Distribution: Rohtak District, Rohtak, *S. Ahmad*, October 10, 1942, 4 plants no. *609* Herb. Ahmad, **type**. Sheikhupura District, Ladhar, *S. Ahmad*, August 25, 1942, 3 plants Herb. Ahmad no. *593*, and 2 plants in Herb. Long no. *11109*, (Ahmad no. *593*).

The outstanding features of this species are its strong resemblance to an acorn in its cup, its deciduous sporocarp and the heavy sandy peridial sheath. The sporocarps when free always fall on their base, with their mouths up, thereby aiding in the dissemination of the spores.

9. Tylostoma psilophilum sp. nov.

FIGURE 9

Sporocarpo depresso-globoso, 4.5–6 mm. alto, 7–18 mm. lato. *Exoperidio* pulverulento, haud toto secedente. *Endoperidio* avellaneo. *Ore* tubulato, prominulo. *Stipite* 4–13 mm. alto, 2–3 mm. crasso, squamuloso, brunneolo. *Sporis* globosis vel subglobosis, 3.8–4.5 μ. *Episporio* luteolo, echinulato.

Sporophore having sporocarp, stipe and bulbous base. *Sporocarp* depressed-globose, 4.5–6 mm. high by 7–18 mm. wide, firmly attached to stem apex. *Exoperidium* hyphal-granular, finally deciduous. *Peridial sheath* a dirt-hyphae irregular band 2–3 mm. wide, semi-deciduous. *Endoperidium* membranous, tough, avellaneous to wood brown. *Mouth* tubular, short, slightly projecting. *Collar* inconspicuous, more or less fimbriate margin, close to stem. *Stipe* 4–12 mm. long by 2–3 mm. thick, straight or

curved with numerous lacerate brown scales, walnut brown. *Base* slightly bulbous. *Volva* none. *Radicating base* none. *Gleba* cinnamon. *Capillitium* hyaline, sparsely septate, little or not swollen at nodes. *Spores* globose to subglobose, 3.7–4.5 μ mean, 4.25 μ. *Epispore* yellowish, sparsely echinulate.

Habitat: In sandy clay soil.

Distribution: Gurdaspur District, Jaggatpur, August 1937, *S. Ahmad*, 9 plants Herb. Ahmad, no. *257*, 4 of these now in Herb. Long, no. *11106*, **type.**

10. Tylostoma amnicola sp. nov.

FIGURE 10

Sporocarpo globoso usque subgloboso, 5–9 mm. alto, 5–10 mm. lato. *Exoperidio* granuloso, toto secedente. *Endoperidio* membranaceo, sublevi, avellaneo. *Ore* tubulato, brevi. *Stipite* 1–2 cm. alto, 1–4 mm. crasso, squamuloso aetate glabrescente, brunneo. *Sporis* ovatis vel subglobosis, 4.2–5.2 μ. *Episporio* verruculoso.

Sporophore having sporocarp, stipe and slightly swollen base. *Sporocarp* globose to subglobose, 5–9 mm. high by 5–10 mm. wide, rather firmly attached to stem apex. *Exopcridium* granular, more or less deciduous. *Peridial sheath* not evident on some plants but pronounced on several loose heads, hyphae and dirt, 1–5 mm. wide, more or less persistent. *Endoperidium* membranous, subsmooth, with fragments of exoperidium and dirt here and there, avellaneous to light cinnamon drab. *Mouth* tubular, short, but evident, small about 1 mm. in diameter. *Collar* definite, 1–2 mm. from stem. *Stipe* 1–2 cm. long by 1–4 mm. thick, terete, even, scaly becoming smooth in age, walnut brown to Roods brown. *Bulb* very small 2–4 mm. thick. *Gleba* Mikado brown. *Capillitium* hyaline, branched, lumen small, septa transverse or ends rounded and then bulbous, usually not or only slightly swollen. *Spores* subglobose to oval, 4.2–5.2 μ in diameter, some apiculate, some uniguttulate. *Epispore* verruculose to smooth.

Habitat: In sandy places on river banks.

Distribution: Bihar Province, Pusa, *E. J. Butler*, no. *641* in Herb. Crypt. Ind. Orient, July 11, 1906, 17 plants in Lloyd Myc. Coll. no *53171*, **type**; 4 plants in Lloyd Myc. Coll. no. *53172a*; no. *637* in Herb. Crypt. Ind. Orient in Lloyd Myc. Coll. no. *53174*. Lahore District on the Ravi River near Lahore, *Dr. Stewart*, May 30, 1867, from Herb. M. O. Cooke, 2 small plants now in Herb. Hort. Kew under name of *Tylostoma Wightii* but certainly not this species. Aligark District (U.P.) from Herb. Forest Research Institute, no. *3885*, Dehra Dun, February 16, 1945, leg. *P. C. Kanjilal*, 10 plants in Herb. Ahmad no. *404*.

11. Tylostoma albocretaceum sp. nov.

FIGURE 11

Sporocarpo subgloboso vel depresso-globoso, 12–14 mm. lato, 8–12 mm. alto. *Exoperidio* pulverulento, toto secedente. *Endoperidio* cretaceo albido, membranaceo. *Ore* tubulato, brevi, elliptico. *Stipite* robusto, 4–4.5 cm. alto, 2–4 mm. crasso, levi, nec squamuloso, albido, volvato. *Sporis* globosis vel ovatis, 4.8–5.2 μ. *Episporio* levi.

Sporophore having sporocarp, stipe, volva and radicating base. *Sporocarp* subglobose to depressed-globose, 8–10 mm. high by 12–14 mm. wide, firmly attached to stem apex. *Exoperidium* a granular dirt coat, partially to completely deciduous. *Peridial sheath* completely deciduous on larger plant and nearly so on the smaller one. *Endoperidium* chalky white, rough from adhering pieces of the exoperidium, membranous. *Mouth* tubular, short, entire, enlarged at base, slightly raised, circular. *Collar* distant from stem, strongly and broadly concave, socket light pinkish cinnamon inside, irregularly fimbriate around edges, about 4 mm. distant from stem apex. *Stipe* white, stout, tapering to base, 4.4–4.5 cm. long by 2–4 mm. thick, smooth, not scaly. *Volva* small, closely clasping the stem, double, having an inner secondary volva consisting of the lacerate fragments of the upper part of the stem cortex. *Radicating* roots, small and short. *Gleba* sepia. *Capillitium* dusky, branched, walls thin to thick, often flaccid, septa not seen. *Spores* globose to subglobose to oval, 4.8–5.2 μ in diameter, contents dusky. *Epispore* smooth, walls dusky.

Habitat: Solitary in clay soil under bushes of *Capparis aphylla*.

Distribution: Rohtak District, Rohtak, October 7, 1945, *S. Ahmad*, 2 plants in Herb. Ahmad no. *1299*, **type.**

This is the only volvate species of *Tylostoma* in India, except *T. volvulatum*, a very unusual circumstance considering the number of species found in the Panjab.

12. Tylostoma cineraceum Long, Lloydia [in press] 1947.

FIGURE 12

Sporophore having sporocarp and stipe, originating 3–5 cm. below the surface of the soil. *Sporocarp* subglobose, small 4–5 mm. high by 7–12 mm. wide, firmly attached to stem apex. *Exoperidium* granular, entirely dehiscent. *Peridial sheath* of dirt and hyphae, irregular, persistent. *Endoperidium* membranous, more or less wrinkled, pale drab gray to drab gray to pale pinkish buff. *Mouth* tubular, tube very short, inconspicuous. *Collar* inconspicuous, close to stem. *Stipe* slender, even, white on upper part where not covered with dirt, 4–8½ cm. tall by 4–5 mm. thick, basal part gone on Indian plant, rough with appressed scurfy scales, slightly striate under scales, straight. *Volva* none. *Radicating base* none. *Gleba* cinnamon. *Capillitium* hyaline, walls medium to thick, 4–9 μ in diameter, septa rare, transverse, not swollen. *Spores* subglobose to oval, uniguttulate, 4–5 μ in diameter. *Epispore* plainly verruculose, walls thin.

Habitat: In soil.

Distribution: **Afghanistan; India.** Baltistan, Skardu Plain, elevation 7250 feet, September 1940, *R. R. Stewart*, 1 plant Herb. Ahmad, no. *622*. (Fig. 12a).

Figs. 6–11. *Tylostoma*, × 1: **6,** *T. xerophilum*, 4 plants; **7,** *T. subsquamosum*, 4 plants; **8,** *T. balanoides*, 4 plants; **9,** *T. psilophilum*, 4 plants; **10,** *T. amnicola*, 7 plants; **11,** *T. albocretaceum*, 2 plants.

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This apparently is the same species collected by Aitchison (his no. *203*) in Afghanistan in Hari-rud Valley, described and figured by Long (1947) under the name *Tylostoma cineraceum*. Afghanistan is quite near Baltistan and has more or less the same type of climate. M. C. Cooke reported (1888) in the records of the Afghan Delimitation Commission, p. 129, 3 collections by Aitchison in the Hari-rud Valley nos. *178*, *181*, *203*, April 7, 11, 1885. Only Aitchison's no. *203* is the above species; the other 2 numbers are something else, and although all 3 collections were called by Cooke *Tulostoma Wightii* Berk., none of them was this species.

13. Tylostoma inonotum sp. nov.

FIGURE 13

Sporocarpo globoso usque depresso-globoso, 5–7 mm. alto, 6.5–10 mm. lato. *Exoperidio* pulverulento, haud toto secedente. *Endoperidio* asperato, roseo-alutaceo. *Ore* tubulato, sat elongato. *Stipite* 8–20 mm. alto, 1.5–2.5 mm. crasso, levi. *Sporis* subglobosis, 4.5–5 μ. *Episporio* verruculoso.

Sporophore having sporocarp, stipe and bulbous base. *Sporocarp* irregularly globose to depressed-globose, 5–7 mm. high by 6.5–10 mm. wide, firmly attached to stem apex. *Exoperidium* hyphal-granular, persistent, pecan brown. *Peridial sheath* of dirt and hyphae, 3–4 mm. wide, persistent. *Endoperidium* rough, due to the adhering exoperidium, pinkish buff. *Mouth* tubular, projecting. *Collar* inconspicuous close to stem. *Stipe* 8–20 mm. long by 1.5–2.5 mm. thick, smooth, very rarely broken into a few irregular scales. *Base* of stipe bulbous; in 2 of the plants stipes and peridia have grown together. *Capillitium* hyaline, branched, septate, 3.2–6.5 μ thick strongly swollen at the nodes which are from 9.6–12.8 μ thick (Fig. A 6). *Spores* globose to subglobose, pale yellowish under the oil immersion lens, 4.5–5 μ in diameter. *Epispore* verruculose.

Habitat: Solitary or gregarious in sandy soil rich in humus, near the base of *Dalbergia sissoo* surrounded by several shrubs.

Distribution: Sheikhupura District, Ladhar, September 15, 1942, 6 plants Herb. Ahmad no. *633*, **type.**

This species has so far been collected only once, but it differs from the other species of the Plains in color of the peridium, verruculose spores, and non-scaly stipe.

14. Tylostoma puncticulosum sp. nov.

FIGURE 14

Sporocarpo subgloboso vel depresso-globoso, 5–8 mm. alto 6–12 mm. lato. *Exoperidio* granuloso, haud toto secedente. *Endoperidio* scrobiculato, albicante, membranaceo. *Ore* subfibrilloso, lacerato, aetate nudo, indefinito. *Stipite* 2–25 mm. alto 1–2 mm. crasso, albicante, aetate cinnamomeo, rugoso vel levi. *Sporis* subglobosis, 4.5–6.6 μ. *Episporio* levi.

Fig. A. Showing capillitium and spores of: **A 1**, *Tylostoma evanescens*; **A 2**, *T. hygrophilum*; **A 3**, *T. puncticulosum*; **A 4**, *T. balanoides*; **A 5**, *T. sedimenticola*; **A 6**, *T. inonotum*. All drawings × 600.

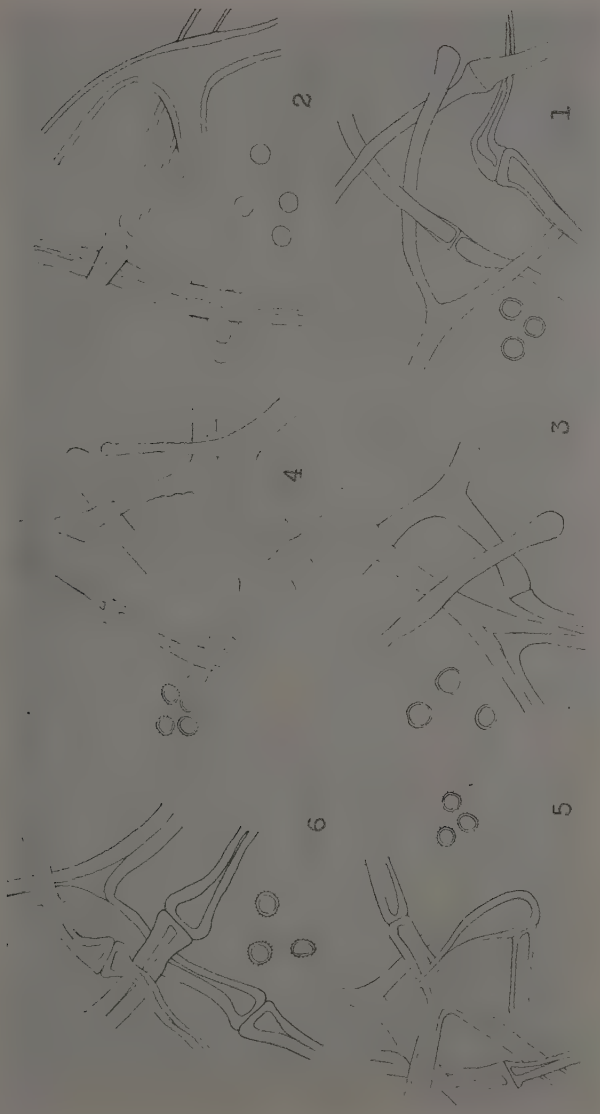


FIGURE A

Sporophore consisting of sporocarp, stipe and slightly bulbous radicating base. *Sporocarp* subglobose to depressed-globose, 5–8 mm. high by 6–12 mm. wide, firmly attached to stem apex. *Exoperidium* granular, long persisting but finally more or less deciduous, then separating with a pitted effect on the endoperidium, when freshly emerged covered with a dense layer of dirt. *Peridial sheath* a layer of sand and hyphae, 2–5 mm. wide, persistent. *Endoperidium* minutely pitted, dingy white to pinkish buff, membranous, tough, often remaining covered by the exoperidium. *Mouth* subfibrillose, fibrils few, granular pitted, losing its scant fibrils and becoming naked, irregular, indefinite and lacerate with age. *Collar* distinct, 1–2 mm. distant from stem. *Stipe* 2–25 mm. long, usual size 15 mm. by 1–2 mm. thick, white when fresh, becoming cinnamon or even darker with age, rugose to nearly smooth, terete, even, not sandy. *Base* slightly enlarged. *Radicating base* with short central root. *Volva* none. *Gleba* ferruginous. *Capillitium* pale yellow to subhyaline 4–5.5 μ thick, branched, somewhat uneven, rarely septate, with slightly swollen nodes (Fig. A 3). *Spores* globose to subglobose, 4.5–6.5 μ in diameter, often apiculate, yellowish. *Epispore* smooth, ochraceous.

Habitat: Solitary in sandy or clayey soil.

Distribution: Sheikhupura District, Sangla Hill, *S. Ahmad*, September 10, 1936, 5 plants in Univ. N. C. Herb. (Ahmad no. *27*) and 3 plants Herb. Long no. *11153* (Ahmad no. *27*); 14 plants in Univ. N. C. Herb. (Ahmad no. *4*) and 7 plants in Herb. Long no. *11152* (Ahmad no. *4*); Ladhar, *S. Ahmad*, September 1936, 36 plants Herb. Ahmad, no. *1288*, 7 of these now in Herb. Long no. *11135;* September 1947, 37 plants Herb. Ahmad no. *300*, 12 of these now in Herb. Long no. *11136*, **type**; April 1938, 40 plants Herb. Ahmad no. *1286*, 10 of these now in Herb. Long no. *11115*. Gurdaspur District, Jaggatpur, *S. Ahmad*, August 19, 1937, 2 plants in Herb. Long no. *11125* (Ahmad no. *303*); August 1938, 7 plants in Herb. Long, no. *11126* and 6 plants no. *11143* (Ahmad nos. *309* and *309a*). Ladhar, September 1937, 3 plants in Herb. Ahmad, no. *310*; September 1939, 71 plants in Herb. Ahmad, no. *311;* August 6, 1944, 20 plants in Herb. Ahmad, no. *312*; September 4, 1944, 7 plants in Herb. Ahmad no. *1281;* August 1944, 9 plants in Herb. Ahmad no. *1293*. Shorkot, August 1938, 23 plants in Herb. Ahmad, no. *621*.

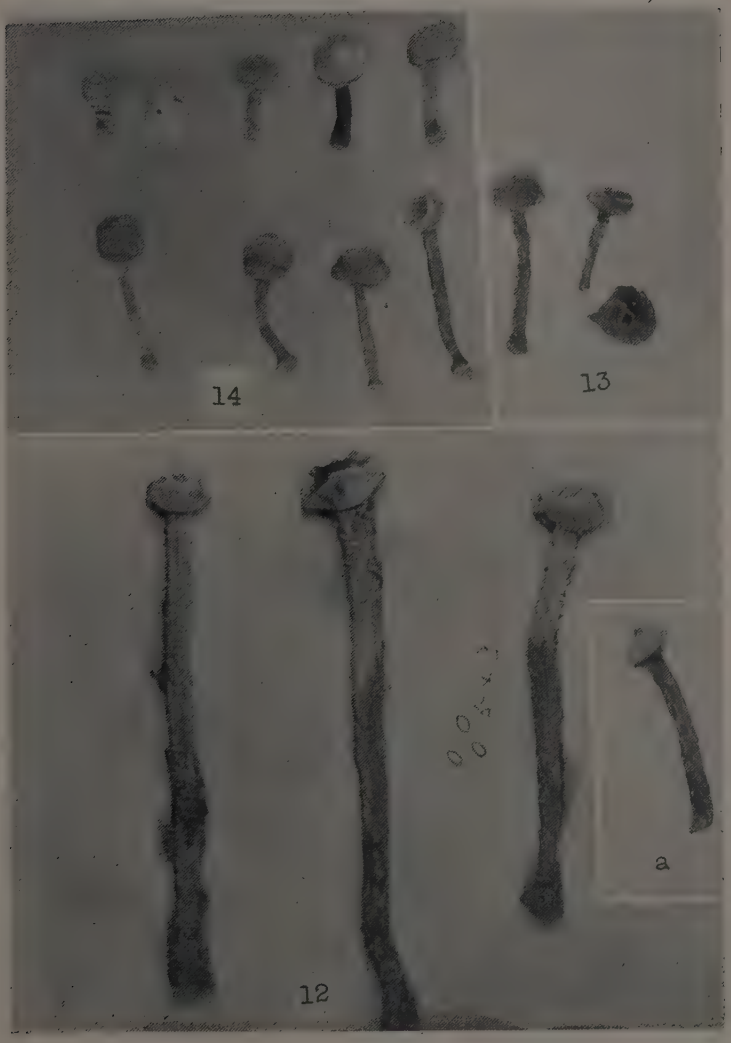
This species was listed by Ahmad (*l.c.*) as *Tylostoma egranulosum* Lloyd.

15. Tylostoma vulgare sp. nov.

FIGURE 15

Sporocarpo subgloboso vel depresso-globoso, 8–12 mm. alto, 10–18 mm. lato. *Exoperidio* granuloso, haud toto secedente. *Endoperidio* membranaceo, avellaneo; asperato. *Ore* subfibrilloso vel indefinito. *Stipite* albicante aetate cinnamomeo, striato vel

Figs. 12–14. *Tylostoma*, × 1: **12,** *T. cineraceum*, 3 plants from Afghanistan, **type; 12 a,** *T. cineraceum*, 1 plant from Skardu, India; **13,** *T. inonotum*, 3 plants; **14,** *T. puncticulosum*, 9 plants.


14
13
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a

sulcato, 8–40 mm. alto, 3–6 mm. crasso. *Sporis* globosis usque ellipticis, 5.4–6.3 μ. *Episporio* crasso, levi.

Sporophore having sporocarp, stipe and slightly bulbous radicating base. *Sporocarp* subglobose to appressed-globose to pulvinate, 8–12 mm. high by 10–18 mm. wide, firmly attached to stem apex. *Exoperidium* granular, persistent to deciduous. *Peridial sheath* a band of hyphae and sand, 3–5 mm. wide, often inconspicuous, persistent. *Endoperidium* membranous, often pitted around the mouth, avellaneous to wood brown, rough from adhering sand, often entirely covered by the sandy exoperidium. *Mouth* subfibrillose, with very scanty fibrils when fresh, slightly raised, becoming naked and indefinite as the exoperidium is shed, pitted and finally irregularly lacerate in age. *Collar* inconspicuous, 1–2 mm. from stem. *Stipe* dingy white when fresh, then cinnamon on weathering, striate to sulcate, not scaly, even, 8–40 mm. long by 3–6 mm. thick, rarely tapering to base. *Radicating base* with a strong root 5–8 mm. long. *Gleba* ferruginous to sayal brown. *Capillitium* hyaline to yellowish, thick-walled, wavy and irregular, branched, septa rare, little or not swollen. *Spores* globose to ellipsoid, yellowish, 5.4–6.3 μ, mean 5.7 μ. *Epispore* thick, smooth.

Habitat: Solitary in open sandy wastes which are covered with a scanty scattered growth of perennial grasses; appearing before the grass starts into growth from the monsoon rains.

Distribution: Sheikhupura District, Ladhar, *S. Ahmad*, August 1939, 105 plants Herb. Ahmad, no. *291*, 9 of these now in Herb. Long no. *11138*; August 20, 1939, 23 plants in Herb. Long, no. *10257* (from Ahmad no. *291a*); August 10, 1941, 103 plants Herb. Ahmad no. *626*, 3 of these now in Herb. Long, no. *11141;* April 14, 1938, 153 plants Herb. Ahmad no. *1289*, 21 of these now in Herb. Long, no. *11101*, **type**; August 15, 1942, 346 plants Herb. Ahmad, no. *1296*, 22 of these now in Herb. Long, no. *11132*; August 8, 1945, 3 plants in Herb. Ahmad, no. *1428*. Sangla Hill, April 1938, *S. Ahmad*, (Ahmad no. *29*), 4 plants now in Herb. Long no. *11156*. Rohtak District, Rohtak, *S. Ahmad*, January 18, 1943, 70 plants Herb. Ahmad no. *680*, 10 of these now in Herb. Long no. *11139*. Ladhar, August 6, 1944, 4 plants in Herb. Ahmad no. *1284*; August 21, 1938, 6 plants in Herb. Ahmad no. *1291*; September 1941, 4 plants in Herb. Ahmad no. *1294*. Sangla Hill, August 1934, 3 plants in Herb. Ahmad, no. *1290*.

This is one of the commonest species of the Panjab Plains. Ahmad (1939) listed it as *Tylostoma australianum* Lloyd, so determined by Dr. W. C. Coker, but it is not this species, as a careful comparison with type material showed.

16. Tylostoma parvissimum Long & Ahmad, Mycologia **38:** 87–88. 1946.
FIGURE 16

Sporophore consisting of sporocarp, stipe and bulbous radicating base. *Sporocarp* ovate, subglobose to depressed-globose, 3–8 mm. high by 5–10 mm. wide firmly attached to stem apex. *Exoperidium* membranous, outer

surface when freshly emerged covered with a thin adnate layer of dry clay, white under clay, slowly deciduous in flakes, leaving lacerate shreds of the dried membrane on spore sac, completely deciduous in age. *Peridial sheath* a band of agglutinated hyphae and clay, 2–3 mm. broad often forming a cup-like membrane, persistent. *Endoperidium* membranous, white, smooth, sometimes pitted, tough. *Mouth* indefinite, often subfibrillose with a few scant fibrils, slightly raised, in old specimens the fibrils are lost and an irregular naked orifice is left. *Collar* 1–2 mm. long, conspicuous, closely clasping the stem, usually covered with dry clay. *Stipe* slender 2–27 mm. long by 1–3 mm. thick, even, white to wood brown, usually smooth to faintly longitudinally striate, rarely with a few appressed scales. *Radicating base* with one stout root, 4–10 mm. long. *Bulb* small 6–8 mm. thick, firm. *Volva* none. *Gleba* clay color to raw sienna. *Capillitium* hyaline, much branched, side branches smaller, 2–6 mm. thick, lumen scant or none, flexuous, ends of threads square, septa rare not swollen. *Spores* globose to broadly oval, uniguttulate in water mount, 4.2–5.4 μ. *Epispore* hyaline to slightly fulvous, about 1 μ thick, appearing granular in water mount, but distinctly and moderately echinulate in chloral hydrate and also in benzoazurin mount.

Habitat: Solitary in clayey soils, common on such areas, in semi-deserts.

Distribution: Rohtak District, Rohtak, *S. Ahmad*, June 15, 1941, **type**, 10 plants in Herb. Long no. *10621*, (Herb. Ahmad no. *338*); July 1941, 6 plants in Herb. Long, no. *11026*, (Herb. Ahmad *338a*) and 11 plants in Herb. Long *11121*, (Herb. Ahmad *338b*); *S. Ahmad*, June 8, 1941, 99 plants Herb. Ahmad *339*, 17 of these now in Herb. Long no. *11127*; October 1941, 45 plants Herb. Ahmad no. *636*, of these 10 now in Herb. Long no. *11129*.

17. Tylostoma membranaceum sp. nov.

FIGURE 17

Sporocarpo globoso usque depresso-globoso, 8–16 mm. alto, 10–22 mm. lato. *Exoperidio* membranaceo, albicante. *Ore* subfibrilloso vel nudo. *Stipite* 1.7–4 cm. alto, 3–6 mm. crasso, brunneo, squamuloso. *Sporis* subglobosis, 4.5–5.5 μ. *Episporio* levi.

Sporophore having sporocarp, stipe and bulbous radicating base. *Sporocarp* globose to depressed-globose, 8–16 mm. high by 10–22 mm. wide, firmly attached to stem apex. *Peridial sheath* covered with dry clay therefore not seen. *Exoperidium* membranous, covered with dried clay, deciduous in age. *Endoperidium* membranous, white to pinkish buff. *Mouth* subfibrillose surrounded by a zone of fibrils which is lost in age, fibrils scanty or even undeveloped in some specimens, small. *Collar* inconspicuous, 1–2 mm. from stem apex. *Stipe* even, terete, 1.7–4 cm. long by 3–6 mm. thick, pecan brown to walnut brown, scaly, with small ascending scales. *Base* bulbous, 6–10 mm. in diameter of hyphae and clay. *Radicating base* present or none. *Gleba* ferruginous. *Capillitium* hyaline. *Spores* globose to subglobose, 4.5–5.5 μ in diameter. *Epispore* smooth.

Habitat: Gregarious among grass in clay soil.

Distribution: Rohtak District, Rohtak, *S. Ahmad*, September 26, 1945, 8 plants Herb. Ahmad no. *1475*, **type**, 3 of these now in Herb. Long no. *11507*. It differs from *Tylostoma parvissimum* in the larger size and more definite fibrillose mouth, brownish scaly stipe and smooth spores. It resembles that species in the membranous exoperidia and the whitish endoperidium. A comparison side by side of this collection with plants of *T. parvissimum* show the 2 are not the same species.

18. Tylostoma Wightii Berk., London Jour. Bot. **1:** 157. 1842.

FIGURE 18

Sporophore having sporocarp, stipe and slightly enlarged base. *Sporocarp* subglobose, 14 mm. high, 18 mm. wide, firmly attached to stem apex. *Exoperidium* of the granular-hyphal type, deciduous on upper part, hyphal layer on lower half persistent, free of dirt, pecan brown to army brown, with a more or less stellate margin. *Peridial sheath* merged with the exoperidium, persistent. *Endoperidium* papyraceus, thin, tilleuil buff, flaccid, wrinkled. *Mouth* flat, fringed-appendage or valvate, obscure on specimen, partially hidden by being pasted on card, fimbriate-lacerate, not tubular, not definite. *Collar* not evident, hidden by being flattened when pasted on card. *Stipe* 2½ cm. long by 3 mm. wide, slightly scaly with appressed peeling scales, slightly curved. *Base* slightly enlarged by ball of dirt and hyphae. *Gleba* hazel. *Capillitium* hyaline, much branched, 4–5 μ thick, ends rounded, some threads flaccid, septa very rare, not swollen, ends of septa transverse, irregularly thickened. *Spores* subglobose, 4.2–5.4 μ diameter. *Epispore* verruculose.

Habitat: Solitary in soil.

Distribution: Near Madras, 1867, 1 plant type in Herb. Hort. Kew, England.

19. Tylostoma exasperatum Mont., Ann. Sci. Nat. (Bot.) II, **8:** 362. 1837.
Tylostoma Ridleyi Massee, Kew Bull. Misc. Inform. **1899:** 173. 1899.

FIGURE 19

Sporophore having sporocarp, stipe and caespitose base. *Sporocarp* subglobose, 10–12 mm. high by 11–18 mm. wide including the long warts. *Exoperidium* a hyphal layer covered by long pointed, conical warts, warts 1–3 mm. long, burnt umber, deciduous on upper part leaving distinct whitish-brown scars. *Peridial sheath* a continuation of the exoperidium, but warts shorter, persistent. *Endoperidium* pecan brown, context soft, surface rough from scars left by the shed warts. *Mouth* valvate, of 4–5 valves, walnut brown or slightly darker. *Collar* inevident, hidden by flattened head. *Stipe* even, scaly, scales flattened and easily shedding, 2–5 cm. long by 3.4 mm. thick, caespitose, burnt umber. *Volva* none. *Radicating base* none. *Gleba* cinnamon. *Capillitium* hyaline to tinted, walls thin,

Figs. 15–17. *Tylostoma*, × 1: **15,** *T. vulgare*, 10 plants; **16,** *T. parvissimum*, 9 plants; **17,** *T. membranaceum*, 3 plants.

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lumen large, small threads hyaline, branched, septa transverse, not swollen. *Spores* globose, with strong halo. 5–5.6 μ exclusive of halo, 6–7 μ including halo. *Epispore* with very prominent halo, spines brown.

Habitat: Apparently on rotting wood in this case.

Distribution: Nilgiris, *Capt. Badham*, 1867, 9 plants from Herbarium Berkeleyeanum now in Herb. Hort. Kew, England.

The above description was made from this Indian collection. This is a very marked species and widely distributed over the world in tropical and subtropical regions according to Long (1947) and other writers.

20. Tylostoma exitum sp. nov.

FIGURE 20

Sporocarpo ovato usque subgloboso, 4–8 mm. alto, 5–11 mm. lato. *Exoperidio* granuloso, haud toto secedente. *Endoperidio* membranaceo, albicante, duro. *Ore* operculato, aetate indefinito, nudo. *Stipite* brevi, 0.5–15 mm. alto, 1–3 mm. crasso, superne squamoso, deorsum denudato, brunneo. *Sporis* subglobosis, 3.7–5.5 μ. *Episporio* luteo, verruculoso.

Sporocarp ovate to subglobose, 4–8 mm. high by 5–11 mm. wide, firmly attached to stem apex. *Exoperidium* granular, more or less adherent, rarely deciduous. *Peridial sheath* a narrow band of sand and hyphae, 2–4 mm. wide, persistent. *Endoperidium* tough, membranous, dingy white to pinkish buff. *Mouth* operculate, a torn aperture, linear or elliptic in form with the torn margin or lid folded backward on one side of the aperture becoming lacerate and indefinite with age, $\frac{1}{2}$–1 mm. diameter. *Collar* inconspicuous about 1 mm. from stem. *Stipe* short, 0.5–15 mm. long by 1–2 mm. thick, even, slightly scaly, covered with lacerate membranous scales for some distance below peridium, cinnamon to pecan brown, smooth, some striate. *Base* slightly bulbous. *Gleba* cinnamon. *Capillitium* hyaline, branched, septa transverse or oblique, thick-walled, mostly about 5 μ thick but some up to 8 μ, septa slightly to strongly swollen. *Spores* globose to subglobose, 4.8–5.5 μ in diameter. *Epispore* pale yellow, distinctly verruculose.

Habitat: In sandy soil on the sides of a water course, not found anywhere else except at one particular spot, and as the water course is cleaned of silt frequently, so it has disappeared and has not been collected for the last 8 years.

Distribution: Sheikhupura District, Ladhar, August 1936, 12 plants Herb. Ahmad no. *1279*; September 1937, 10 plants Herb. Ahmad no. *296*, and 7 plants in Herb. Long no. *11157*, **type**, (no. *26* Herb. Ahmad) from Sangla Hill; August 25, 1938, 15 plants in Herb. Ahmad no. *471*. This plant was originally listed by Ahmad as *T. adhaerens* following Dr. W. C. Coker's tentative identification as a small form of this species. It

Figs. 18–19. *Tylostoma*: **18,** *T. Wightii*, 1 plant, **type**, from Herb. Hort. Kew, $\times$ 1; **19,** *T. exasperatum*, 6 plants from Nilgiris, India, $\times$ 1; **19 a,** *T. exasperatum*, showing the valvate mouth, $\times$ 2.

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18

has been compared with authentic material of the true *T. adhaerens* and found to be an entirely different species.

21. Tylostoma operculatum sp. nov.

FIGURE 21

Sporocarpo depresso-globoso, 4–10 mm. alto, 5–14 mm. lato. *Exoperidio* granuloso, haud toto secedente. *Endoperidio* membranaceo, crasso, cinnamomeo. *Ore* operculato, aetate indefinito. *Stipite* 8–15 mm. alto, 3–5 mm. crasso, levi, striato. *Sporis* globosis vel subglobosis luteis, 4.2–5.2 μ. *Episporio* fulvo, levi.

Sporophore having sporocarp, stipe and bulbous radicating base. *Sporocarp* depressed-globose, 4–10 mm. high by 5–14 mm. wide. *Exoperidium* granular, firmly attached to stem apex, semi-deciduous. *Peridial sheath* a layer of hyphae and dirt, 3–4 mm. wide. *Endoperidium* thick, tough, cinnamon, long covered by the exoperidium, membranous. *Mouth* operculate, a definite orifice formed by the tearing apart of the apical portion, which persists on the margin as an irregular lid but becomes more or less indefinite in age under weathering; this operculate mouth is very pronounced on fresh specimens. *Collar* conspicuous 2–3 mm. distant from stem, with a lacerate margin. *Stipe* rather stout, 6–14 mm. long by 3–5 mm. thick, often striate, even or dilated either toward base or toward apex, avellaneous. *Base* bulbous and radicating. *Gleba* cinnamon. *Capillitium* hyaline, branched, sparsely septate, slightly swollen at the nodes. *Spores* globose to subglobose, pale yellowish, uniguttulate, 4.5–5.2 μ. *Epispore* fulvous, smooth.

Habitat: On ground in rich clay.

Distribution: Gurdaspur District, Jaggatpur, August 1938, *S. Ahmad*, 32 plants Herb. Ahmad no. *308*, **type**, 5 of these now in Herb. Long no. *11116;* August 20, 1938, 2 plants in Herb. Ahmad *308a*, now in Herb. Long, no. *11146*. Sargodha, *S. Ahmad*, July 1940, 2 plants in Herb. Ahmad no. *398*.

22. Tylostoma crassipes sp. nov.

FIGURE 22

Sporocarpo subgloboso usque depresso-globoso, 3–8 mm. alto, 5–12 mm. lato. *Exoperidio* hyphali, nec verrucoso, avellaneo, tarde deciduo. *Endoperidio* membranaceo, albicante. *Ore* indefinito, nudo. *Stipite obeso*, 2–20 mm. alto, 3–6 mm. crasso, rugoso, parum striato. *Sporis* subglobosis usque pyriformibus, 4.2–5.6 μ. *Episporio* levi.

Sporophore having sporocarp, stipe and radicating base. *Sporocarp* subglobose to depressed-globose, 3–8 mm. high by 5–12 mm. wide, firmly attached to stem apex. *Exoperidium* hyphal, inner layer of hyphae continuous, very thin, long persistent, not verrucose, very slowly deciduous, avellaneous, similar to *T. verrucosum* but not warted. *Peridial sheath* an extension of the exoperidium, very inconspicuous, persistent. *Endoperidium* white to pinkish buff, membranous, long covered by the exoperidium. *Mouth* indefinite, naked, irregularly orbicular, enlarging with age, small from 0.5 mm. when young to 1½ mm. in age. *Collar* definite, descending

around top of stem slightly, with laciniate edges close to stem. *Stipe* stout, short, 2–20 mm. long by 3–6 mm. thick, even, rugose, sometimes striate, with adhering dirt, scales none, pinkish buff under the dirt. *Volva* none. *Radicating base* with roots 3–5 mm. long, slender. *Gleba* ferruginous. *Capillitium* hyaline, flaccid, 4–5 μ thick, branched, septa not seen. *Spores* subglobose, oval to pear shaped, 4.2–5.6 μ in diameter, sub-hyaline. *Epispore* smooth.

Habitat: In sandy to clayey soil.

Distribution: Gujranwala District, Gakkhar, *S. Ahmad*, August 1942, 185 plants Herb. Ahmad no. *634*, 25 of these now in Herb. Long no. *11137* **type**; August 15, 1941, 163 plants Herb. Ahmad no. *512*, 23 of these now in Herb. Long no. *11142*. Shahkot, *S. Ahmad*, July 18, 1939, 9 plants in Herb. Ahmad no. *623*. This species is characterized by its relatively stout stem, hyphal exoperidium and indefinite mouth.

23. Tylostoma albiceps sp. nov.

FIGURE 23

Sporocarpo subgloboso, 6–10 mm. alto, 10–15 mm. lato. *Exoperidio* granuloso, haud toto secedente. *Endoperidio* albo. *Ore* indefinito. *Stipite* crasso, 3–3.5 cm. alto, 4–5 mm. crasso, levi. *Sporis* subglobosis vel ovatis, 4–5 μ diameter. *Episporio* verrucoso.

Sporophore having sporocarp, stipe and bulbous radicating base. *Sporocarp* subglobose, 6–10 mm. tall by 10–15 mm. wide, firmly attached to stem apex. *Exoperidium* granular, semi-deciduous. *Peridial sheath* of sand and hyphae, 4–5 mm. wide, persistent. *Endoperidium* white, rough with fragments of exoperidium and dirt, membranous. *Mouth* indefinite, small, circular, not raised. *Collar* inconspicuous, more or less clasping the stem. *Stipe* stout, straight, 3–3½ cm. long by 4–5 mm. thick, even, tilleuil buff, not scaly, cortex sometimes shedding. *Base* slightly bulbous and radicating. *Volva* none. *Gleba* cinnamon. *Capillitium* hyaline, branched, lumen small, threads 6–7 μ thick, no septa seen. *Spores* subglobose to oval, 4–5 μ in diameter, with a slight halo. *Epispore* verrucose, walls dark brown.

Habitat: Solitary in sandy soil.

Distribution: Rohtak District, Rohtak, *S. Ahmad*, June 1941, 2 plants Herb. Ahmad, no. *1293*, **type**.

24. Tylostoma perplexum sp. nov.

FIGURE 24

Sporocarpo subgloboso, 3–5 mm. alto, 5–10 mm. lato. *Exoperidio* pulverulento, nec toto secedente. *Endoperidio* membranaceo, albicante. *Ore* indefinito. *Stipite* 3–35 mm. alto, 2–3 mm. crasso, levi, brunneo. *Sporis* subglobosis usque ovatis, 4.2–5 μ. *Episporio* verruculoso.

Sporophore having sporocarp and stipe. *Exoperidium* granular, slowly deciduous on some plants and covering the heads of many. *Peridial sheath* granular, 2–3 mm. broad, persistent. *Endoperidium* pinkish buff, rough from fragments of the exoperidium and dirt. *Mouth* indefinite, irregularly

lacerate, circular to oval. *Collar* free or clasping the stem, slightly lacerate, more or less pendent around the stem. *Stipe* 3–35 mm. long by 2–3 mm. thick, smooth (not scaly), more or less striate, pecan brown. *Base* not radicating, slightly enlarged. *Volva* none. *Gleba* cinnamon. *Capillitium* hyaline, branched, 5–6 μ thick, septa transverse, not swollen, lumen small. *Spores* subglobose to oval, 4.2–5 μ in diam. *Epispore* verruculose.

Habitat: In sandy wastes.

Distribution: Sheikhupura District, Ladhar, *S. Ahmad*, August 1938, 33 plants Herb. Ahmad no. *295*, 7 of these now in Herb. Long no. *11149*, **type**.

Stipes on many plants long in comparison with the size of heads.

25. Tylostoma volvulatum Borszczow, Zapiski Imp. Acad. Nauk St. Petersbourg **7**: 189. 1865.

Tylostoma Boissieri Kalchb. Rev. Mycol. **3**: 24. *pl. 15, fig. 2.* 1881.
Tylostoma Barbeyanum Henn. Bull. Herb. Boissier **1**: 99. 1893.

FIGURE 25

Sporophore having sporocarp, stipe, volva and radicating base. *Sporocarp* subglobose to depressed-globose, 7–26 mm. high by 12–52 mm. wide, prominently concave at insertion of stipe, firmly attached to stem apex. *Exoperidium* semi-membranous, 1 mm. thick, deciduous, (Fig. 25c) often leaving some sand on the endoperidium, which finally falls off, thus becoming completely deciduous. *Peridial sheath* usually completely deciduous. *Endoperidium* white when young soon becoming light buff to cinnamon, membranous, tough, often with large circular wart-like excrescences which sometimes fall out leaving holes through to the gleba, minutely asperate or becoming smooth in age, minutely pitted around mouth in some plants. *Mouth* solitary, indefinite, central, naked, circular rarely with slightly raised edges from extrusion of gleba, which are friable and crumbling to enlarge the stoma to an irregular circular or oval orifice, rarely truly lacerate; only one true mouth, but a few plants may have 2–5 openings produced by wart-like excrescences on the endoperidium, dropping out, leaving holes simulating true stomata (Fig. 25b), 0–6 mm. in size, usually 2–4 mm. rarely splitting under extreme weathering. *Collar* from inconspicuous to prominent, margin on some irregularly fimbriate from fragments of stem cortex, rarely the upper part of volva adheres to the collar (Fig. 25d), socket usually large and strongly concave, rarely flat. *Stipe* even to attenuate downward, 1–15 cm. long by 4–18 mm. thick, apex dilated, usually straight, rarely curved or tortuose (Fig. 25a), smooth when first emerged, the outer cortical layer caducous, often in large flakes or scales, thereby exposing the next layer which is white when fresh but soon becomes pinkish buff to cinnamon, hard, striate to strongly sulcate, woody, walls thick, lumen small having a prominent white myce-

Figs. 20–24. *Tylostoma*, × 1: **20,** *T. exitum*, 7 plants; **21,** *T. operculatum*, 7 plants; **22,** *T. crassipes*, 6 plants; **23,** *T. albiceps*, 2 plants; **24,** *T. perplexum*, 4 plants.

23
24
22
20
21

lial strand. *Volva* very large, firm, cup-shaped, 10–25 mm. wide by 8–10 mm. high, covered with sand, persistent, context dingy white, base of stem inside volva slightly enlarged. *Base* radicating, roots central, stout, 6–12 mm. thick, several cm. long, usually only 4–10 mm. long in herbarium specimens. *Gleba* Kaiser brown to hazel. *Capillitium* colored, branched, septa very rare, slightly swollen. *Spores* globose to ellipsoid, 3.7–5.2 μ in diameter. *Epispore* hyaline to slightly yellowish, medium thick, smooth.

Habitat: Solitary, usually in deep sand.

Distribution: Sheikhupura District, Sangla Hill, *S. Ahmad*, September 1936, 7 plants in Herb. Univ. N. C. (Ahmad no. *3*); August 19, 1937, 4 plants in Herb. Univ. N. C. (Ahmad no. *22*). Sargodha District, Sargodha, April 1937, 11 plants in Herb. Ahmad no. *302* and 2 plants in Herb. Univ. N. C. (Ahmad no. *31*); August 1938, 22 plants Herb. Ahmad no. *233*, 4 of these now in Herb. Long no. *11151*. Rohtak District, Rohtak, June 1939, 15 plants in Herb. Ahmad, no. *240*; June 1939, 81 plants Herb. Ahmad, no. *301*, 48 of these now in Herb. Long no. *11138*; May 25, 1940, 6 plants in Herb. Long no. *10258*; June 25, 1939, 30 plants in Herb. Long no. *11112*; July 1939, 12 plants in Herb. Ahmad no. *311* (abnormally long stipes were found on 6 of these plants, measuring up to 18 cm. while the peridia were comparatively smaller, 1.4–2.6 cm.). 4 plants in Herb. Long no. *11150* (Ahmad no. *311*); August 1939, 118 plants Herb. Ahmad no. *313*, 33 of these now in Herb. Long, no. *11137*; June 10, 1940, 60 plants in Herb. Ahmad no. *340*; 140 plants in Herb. Ahmad no. *341*; 4 plants in Herb. Ahmad no. *485* (in one plant the stipe is 2 cm. thick); June 1942, 2 plants in Herb. Ahmad no. *491* (the apex of the stipe on 1 plant is flattened exactly as in *Chlamydopus* and this feature is also found in some other plants but not so pronounced); July 1939, 2 plants in Herb. Long no. *11111* (Ahmad no. *1487*); June 1940, 33 plants in Herb. Long no. *11113* (Ahmad no. *1488*); October 15, 1945, 3 plants in Herb. Ahmad no. *1491*. Sheikhupura District, Ladhar, April 8, 1938, 8 plants in Herb. Ahmad, no. *574*; September 7, 1945, 6 plants in Herb. Ahmad no. *1450*; 4 miles north of Shahkot, September 13, 1941, 3 plants in Herb. Ahmad no. *1457*. Bahawalpur State, Pallah, July 16, 1944, 9 plants in Herb. Ahmad, no. *1285*.

One specimen in Ahmad collection no. *301* measured as follows: peridium 3.4 cm. in diameter, 2 cm. high, mouth a torn aperture 8 mm. wide, stipe 14 cm. long, 1.3 cm. thick at apex and 8 mm. thick at base, volva 2.2 cm. in diameter. Ahmad collection no. *302* had many small plants, some only 1.3 cm. in diameter by 6 mm. high and stipe 26 mm. long by 9 mm. thick; this was due to long dry periods in which the plants did not reach their normal sizes.

Fig. 25. *Tylostoma*, × 1: **25,** *T. volvulatum*; **25 a,** Shows plant with twisted stem; **25 b,** Shows plant with several mouths; **25 c,** Shows plant with piece of exoperidium still attached to endoperidium; **25 d,** Shows remains of volva attached to base of peridium around top of stipe. Specimen from Africa.

a
b
c
d
25

Many specimens of *Tylostoma volvulatum* have been deposited in the Herb. Crypt. Ind. Orient at New Delhi, India.

There are several species of *Tylostoma* given by various writers as synonyms of *T. volvulatum*. Hollós lists the following: *T. Boissieri* Kalch., *T. kansense* Peck, *T. meyenianum* Morgan, *T. Jourdani* Pat., *T. obesum* C. & E., *T. gracile* White, *T. tortuosum* Ehrenb., *T. Schweinfurthii* Bres. and *T. Barbeyanum* Henn. Some of these are certainly not synonyms. *T. obesum* belongs to an entirely different section, those with fibrillose mouths; *T. gracile* is not a *Tylostoma* but is a small specimen of *Chlamydopus meyenianus* according to Long (1946). *T. Schweinfurthii* is *Schizotoma laceratum*. Long has examined authentic material of *T. Jourdani* collected by Schweinfurth in Africa from the Herbarium of Patouillard, also the type of *T. kansense* and found that these two species are not *T. volvulatum*; how accurate the other determinations of Hollós are we do not know.

We have been unable to locate the type or authentic specimens of *Tylostoma volvulatum* for examination, but from descriptions and figures of this species we are following Sorokin's (1890) and Patouillard's conception of this species. We have seen specimens identified by Patouillard as *T. volvulatum* and they agree in detail with our plants hence we are calling our fungus *Tylostoma volvulatum*, although they do not agree in every way with the original description given by Borszczow (1865) for the species. Many of these earlier descriptions do not give the salient features by which one can identify the species, in fact it is usually impossible to be certain just what plant the author described without examining, side by side, his type plants with ones under study.

According to Lloyd (1906) *Tylostoma tortuosum* and *T. Ruhmerianum* are synonyms of *T. volvulatum* but no authentic specimens of these have been seen, hence we cannot say as to the accuracy of Lloyd's assumption. We have examined authentic specimens of *T. Boissieri* and *T. Barbeyanum* and agree with Patouillard that they are synonyms of our species.

Tylostoma volvulatum apparently is a common plant of wide distribution in North Africa, Central Asia, including India, and Central Europe. Coker & Couch (1928) report what they call a slender form of *T. volvulatum* from Puerto Rico in Seaver and Chardon collection no. *142*, but it is very doubtful if this is the true *T. volvulatum*, judging from their description.

Tylostoma volvulatum was abundantly collected from mounds of sandy loam about one mile toward the east of Rohtak town; strangely enough it is rare on the sand hills to the north and south.

For 4 years (1935–1938) the rains in Rohtak District had practically failed and the whole area was in the throes of a very severe famine. In 1938 the monsoons were once again heavy and occurred at the normal time. During this and the succeeding year (1939) *T. volvulatum* was so abundant that bags full of it could be collected without much difficulty. But since then it has gradually disappeared and at the present (1946) it is hard to find many specimens in spite of diligent search. The reason for

this appears simple, because since the soil remained untilled during this period there was ample chance for the plant to establish itself and complete its full growth undisturbed from year to year. It may be noted that even during this period there was sufficient rainfall but it was so irregular that it was of no use to the crops. With the return of normal climatic conditions the areas where the plants formerly thrived were brought under cultivation and thus the soil was ploughed, the plants were frequently uprooted and their rhizomorphs killed by exposure to the severe heat of the summer.

Apparently the spores play a very insignificant role in reproducing this *Tylostoma* and other species with stout rhizomorphs. Ahmad has observed that many species in India cannot tolerate the least disturbance but prefer to retire to the secluded arid regions where they may grow undisturbed from year to year. Long has noticed the same thing in the United States where any disturbance of the surface soil results in the disappearance of species of *Tylostoma* for at least 5–7 years.

As previously stated, in May and June very hot winds blow during the day-time in the Panjab; at times they increase their severity to such an extent as to take the form of dust storms. The strong wind and the dust storms keep the loose sand shifting from one place to another, depositing it around isolated bushes in the form of low sand hills or dunes. During the course of their action they remove the soil from around many plants thereby exposing their root systems. This is a matter of common observation in all sandy regions and has been observed in several areas in the Panjab Plains. Under these conditions the plants of *Tylostoma volvulatum*, at all stages of development, are unearthed and lie scattered on the surface of the soil. Most of the plants of this species collected from Rohtak were found in this condition. During this process several of the sporocarps are unearthed but there are many others which are buried under sand at different depths; the length of the stems usually depends upon the depth of the soil.

Another factor which influences the growth of the plant is the moisture content of the soil. In sandy soil the water percolates easily to the deeper layers which retain it longer than the upper strata, which further lose their water by evaporation. Taking into account this factor we find that the sporocarps which are buried in the superficial layers cannot grow to their full extent and consequently remain dwarfed with thick stems. On the other hand the sporocarps which are buried very deep down continue to grow and complete their full development in normal course. In this case the large fruit bodies are formed and the stipe especially is very long. It is interesting to note that in some individuals exposed to the severe heat of the summer the outer layers of the already formed stipe die and lose their power to elongate further; with the approach of the favorable season the inner layers elongate further while the outer break up and form large irregular scales. This is further substantiated by the study of *Podaxon pistillaris* and *Phellorina inquinans*, two other sand loving species. The

young stages are generally deep seated and provided at the base with very stout rhizomorphs for the absorption of water. This habitat is very essential for these plants as their gleba matures above the surface of the soil. If their origin is superficial it has been observed that the development of the gleba is soon arrested and the plants remain small and stunted. If the fruit bodies start deeper in the soil where water is available even after the rains are over, they assume very large size and the gleba reaches full maturity in due course of time. *Tylostoma volvulatum* differs from these plants in that the stipe begins to elongate only after the gleba has neared maturity. It is common, therefore, to find plants with mature spores in which their stipes have not yet elongated. Often if these plants are buried in moist soil their stipes complete their development. It is interesting to note in this connection that the button stages which were lying exposed to the severe heat of the summer often elongate their stipes when they get buried in moist sand. This *Tylostoma* has thus remarkably adapted itself to this mode of life, and exposure to hot summer sun does not affect it much. The dispersal of the spores takes place when the mature plants are carried from place to place by the strong winds or when they are violently shaken by the sand striking against their peridia.

It may not be out of place here to mention that the size of the fruit bodies of *Lycoperdon pusillum*, another species occurring in sandy soil in the Panjab, also depends upon the amount of water present in the superficial layers of the soil. As this plant is epigeous the effect is more pronounced in this case than in the species discussed above. When the plants grow on raised soil where water cannot collect they are of very small size but in low places where water from adjacent areas collects they become very large. As the time for full development allotted to this plant by nature is short it has a remarkable power of maturing its gleba no matter at what stage its growth is arrested. It stands at a distinct disadvantage when compared to the other species found in the same habitat which are hypogeous in their earlier stages.

The same two factors effect the growth of other species of *Tylostoma*; if the general level of the ground is higher than the surroundings, rain water easily drains off and has little time for percolating into the lower layers. It is especially true of sandy clay and clay soils. The former has been found to behave like the latter when it lies fallow for a long time. The lower layers then become hard and unsuitable for the growth of the larger species of *Tylostoma*, while the superficial layers can harbor only the tiny species so characteristic of the Panjab Plains. Furthermore the rain falls at intervals during which the upper layers soon lose all their moisture and for this reason the *Tylostomas* regularly experience dry and wet periods of short duration even during the rainy season. This seriously affects their growth. For the same reason a species of *Simblum* found in the same habitat takes very long to produce fully grown plants which are then very small in size.

Even when the lower layers are not so hard as to become unfit for large

species of *Tylostoma*, the character of the soil gets modified by the presence of the grass roots. If the soil is covered with annual species like *Aristida mutabilis*, *A. adsenscionis*, *Eragrostis tremula* and *Bulbostylis barbata* the soil is fit for the growth of *Tylostoma volvulatum*, the giant species. It is the perennial species like *Eleusine flagellifera*, *Dactyloctenium scindicum*, *Sporobolus arabicus* and *Cyperus conglomeratus* which debar the larger species of *Tylostoma* from growing there. The root systems of these grasses are so well developed as to form an entangled mass of dead and living roots. In this condition it is unfit for the *Tylostomas* but a thin layer of soil deposited annually harbors a good number of the midget species. This is a favorable resort of *T. evanescens* and *T. vulgare*; the latter, however, prefers the soil with more scattered grass and is consequently bigger in size. Due to the thick mat of grass roots the sporocarps cannot originate in the deeper layers. If by chance any spores should develop in the lower layers the peridia do not reach the surface. In digging out the *Tylostomas*, some individuals are found with curved stipes entangled in the mass of roots.

For the same reason *T. hygrophilum* has a superficial origin as it grows among dense tufts of grass (*Cynodon dactylon*) but in this species the length of the stipe is determined by the height of the grass; although there is no dearth of water yet the sporocarp is not big in size since it is not allowed sufficient lateral growth, being crowded by the grass.

The midget species of *Tylostoma* under discussion might have originated by reduction under the influence of edaphic and climatic factors but now their small size seems to have become fixed. They also have one advantage of growing among grass, since the root system firmly binds the soil and there is no chance of the exposure of the button stages and the rhizomorphs, so they remain undisturbed from year to year. The sporocarps take more than one season to reach maturity and during the dry period they simply lie in a dormant state, resuming their growth in April (after the winter rains), or in June or July (the beginning of the monsoon rains). This explains why, with the first showers of monsoon rains, *Tylostomas* come up in large numbers while late in the season they are absent, possibly only those which started their development rather late during the last year.

The midget species feel the disturbance much more than the larger species and when the soil where they are growing is brought under cultivation they have never been observed again, even if the soil remains undisturbed for a number of years afterwards.

When the monsoon showers are heavy, the peridia may break off and roll about on the ground disseminating spores. In some cases the peridial walls become flaccid when moist and as drops of rain water fall on them clouds of spores are seen escaping through the mouth. The capillitia in which the spores remain entangled probably serve as a check on their dispersion, so that they may not escape all in one lot; after the spores are discharged the peridia often collapse.

In the Panjab Plains most of the species have the granular type of

exoperidium. As the rains generally occur at short intervals, so it is rare to find plants in which the exoperidia is entirely lost. During the monsoon, rains fall in very heavy torrents breaking away the peridia unless they are protected by grass, etc. This explains to some extent why the plants are covered with mud; since under the circumstances explained above there appears to be little or no chance of the adhering sand or mud being washed off.

We have tried to include in this paper all species of *Tylostoma* heretofore reported from India. Butler and Bisby (1931) reported 5 species, but 2 of these, *Tylostoma Bonianum* and *T. pusillum*, apparently have not yet been found in India. The Director of the Royal Botanical Gardens at Kew writes that neither of these is present in the collections at Kew and that apparently the inclusion of *T. pusillum* in the original description by De Toni *in* Saccardo (1888) as being found at Madras was an error, as this species has been reported only from Borneo. Lloyd (1906) reported that he saw what he took to be *T. Bonianum* at Kew but this seems to be not true and the plant he saw was probably a specimen of *T. exasperatum*. In view of the above we have not included these species in our list of *Tylostomas* from India.

This paper is just a beginning on the number of species of *Tylostoma* in India, as a thorough search of this vast region will undoubtedly bring to light many more species.

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